Caltrans

BMP
Retrofit
Pilot Program

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BASIS OF DESIGN REPORT DRAINAGE DESIGN, DISTRICT 7 Procurement A

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ACRONYMS

BMP	Best Management Practice
Caltrans	California Department of Transportation
DII	Drain Inlet Insert
MS	Maintenance Station
PS&E	Plans, Specifications and Estimates

1.0 INTRODUCTION

1.1 General

This report documents the appropriate design elements employed in the design of five different types of Best Management Practice (BMP) Retrofit Facilities at eight individual locations within Caltrans District 7. The types of BMPs and their respective locations are presented in Table 1-1. The overall purpose of the BMP Pilot Retrofit Studies is to evaluate the removal efficiency for constituents of concern, technical feasibility, and costs of retrofitting Caltrans facilities with BMPs. The content of this report will be confined to documenting the hydrologic characteristics, water quality design parameters and the hydraulic factors considered during the design phase of the program.

TABLE 1-1
Procurement Package BMP Sites

SITE NO.	BMP TYPE	BMP LOCATION
1a	Infiltration Trench	Altadena Maintenance Station, 2122 North Windsor Ave., I-210 Fwy North Windsor Ave. Offramp
1b	Biofiltration Strip	Altadena Maintenance Station, 2122 North Windsor Ave., I-210 Fwy North Windsor Ave. Offramp
2a	Biofiltration Strip	Area between Northbound I-605 / Westbound SR-91 connector, Eastbound SR-91 / Northbound I-605 connector, and Westbound SR-91 / Southbound I-605 connector
2b	Biofiltration Swale	Area between Northbound I-605 / Westbound SR-91 connector, Eastbound SR-91 / Northbound I-605 connector, and Westbound SR-91 / Southbound I-605 connector
3	Biofiltration Swale	Ditch between south side of Cerritos Maintenance Station and Westbound SR-91
4	Biofiltration Swale	Area between Southbound I-5, Southbound I-5 / I-605 connector, and Southbound I-605 / Florence Offramp
5	Biofiltration Swale	I-605 Northbound shoulder between Centralia overcrossing and Del Amo Blvd.
6	Drain Inlet Insert	Foothill Maintenance Station, 850 East Huntington Drive, at corner of Mountain Ave.
7	Drain Inlet Insert	Las Flores Maintenance Station, 2503 Las Flores Canyon Road, one half mile north of Pacific Coast Highway
8	Drain Inlet Insert	Rosemead Maintenance Station, 9153 Lower Azusa Road, one quarter mile east of Rosemead Blvd.

1.2 Objectives

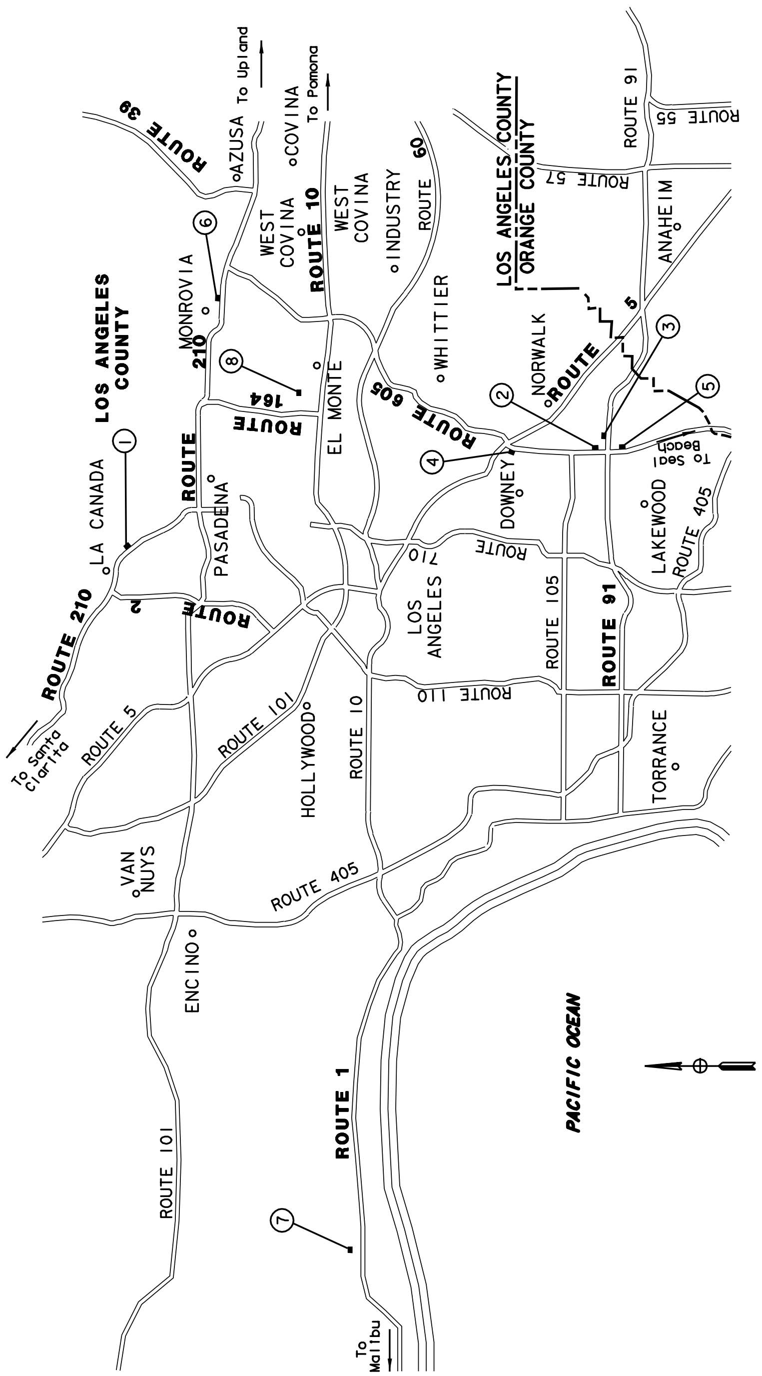
The objective of the design of the BMP Retrofit Pilot Facilities was to follow, as close as possible, the design guidelines provided in the *Scoping Study, Retrofit Pilot Program, Caltrans District 7* prepared by Robert Bein, William Frost and Associates dated April 28, 1998, while complying with applicable Caltrans District 7 site-specific requirements. Deviations from these design guidelines will be noted in Section 3 of this report.

1.3 Project Locations

The location of each BMP Retrofit Facility within Los Angeles County is presented in Figure 1-1. All project locations are the same as those proposed in the *BMP Retrofit Pilot Program Composite Siting Study, District 7* prepared by Robert Bein, William Frost and Associates dated April 9, 1998. No deviations from the Siting Study were necessary. As shown, the sites are spread across the county, most with 1 hour of each other. Four sites are located within Caltrans maintenance stations, one is located immediately outside a maintenance station, and the remaining three are located along the shoulder of interstate roadways.

1.4 Construction Cost

The preliminary engineer's estimated cost of construction for the eight BMP sites is $1,005,185. This estimate is based on quantity of work items extracted from the design, and current Caltrans cost data (*1996 Contract Cost Data, Revision No. 1, 8/97*). A copy of the Engineer's Estimate is provided in Appendix E.



LOC	ROUTE	KP	PM	DESCRIPTION
1	210	36.19	22.49	ALTADENA MAINTENANCE STATION
2	605	8.18	5.08	N 605 / N 605 & W 91 SEPARATION
3	91	27.46	17.06	W 91 NEAR CERRITOS MAINTENANCE STATION
4	5	11.18	6.95	S 5 / S 5 & S 605 SEPARATION
5	605	3.18	1.98	N 605/CARSON & DEL AMO OVERCROSSINGS
6	210	55.91	34.74	FOOTHILL MAINTENANCE STATION
7	1	71.00	44.12	LAS FLORES MAINTENANCE STATION
8	164	10.69	6.64	ROSEMEAD MAINTENANCE STATION

BMP LOCATIONS
FIGURE 1-1

2.0 HYDROLOGIC CHARACTERISTICS

One of the first and most important steps prior to hydraulic design of a BMP facility is estimating the discharge rate or volume of runoff that the BMP will be required to convey, control, and treat. To effectively design the BMPs, peak discharge rates and/or total rainfall volumes for design storm events were calculated. In accordance with study guidelines, one-year and 25-year design storm events were used to design the BMPs. In the specific case of the infiltration trench, another important hydrologic process considered in the design was the infiltration of surface water to the soil. Understanding native soil conditions and infiltration rates provided necessary information in the sizing of this BMP.

The following sections describe in detail the approach used in estimating the peak discharge rates and total rainfall volumes, and the sources of hydrologic data used in the analysis.

2.1 Rainfall Characteristics (Parameters)

Rainfall characteristics utilized in the design include:

- Intensity (rate of rainfall),
- Duration (time rainfall lasts), and
- Frequency (statistical probability of how often rainfall will occur).

Sources of rainfall data include the Caltrans Average Intensity Duration Curves for District 7; staff at the Los Angeles County Department of Public Works (LACDPW); and the *Scoping Study, Retrofit Pilot Program, Caltrans District 7,* prepared by Robert Bein, William Frost and Associates dated April 28, 1998.

The amount of rainfall from a 1 year, 24 hour storm was estimated by Brown and Caldwell using rain gauge stations within the study area (Brown and Caldwell, *Caltrans Storm Water Facilities Retrofit Evaluation*, May 1997). Rainfall values were determined using precipitation records from 1944 to 1995 (24-hour rainfall totals) from the Los Angeles International Airport (LAX) weather station. The data was analyzed using the log-Pearson type III method and by the annual series data method. Also, a second and third set of rainfall records were analyzed from the Van Nuys and the downtown Los Angeles weather stations. Both locations were used to compare with the information gathered from LAX because all of the stations are located in the same rainfall region (coastal plain) as defined by the Los Angeles Department of Public Works (LACDPW).

At the LAX weather station, the calculated 1 year, 24 hour rainfall equaled 0.5-inches (log-Pearson) and 1.12-inches (annual series data method). Two extreme drought years may have influenced the outcome of the log-Pearson analysis. The Van Nuys and downtown Los

Angeles stations were 0.71 and 0.73-inches, respectively, using the annual series data method. From the results, the exact size of the 1 year, 24 hour storm event is uncertain. The study concluded that 1 inch of rainfall is slightly greater than what the log-Pearson method estimates, and slightly less than what the annual series method estimates. It was therefore determined that 1.0 inches was a reasonable value for the Los Angeles Coastal Plain (Caltrans Zone K, see Appendix A Hydrology), and was used to design and size each BMP.

2.2 Soil Types and Infiltration

One of the BMPs that will be evaluated is an infiltration trench (Site 1a - Altadena Maintenance Station). An infiltration trench requires permeable soils or subsoils to function properly. As presented in the Scoping Study, a minimum infiltration rate of 1.94×10^{-4} cm/s is required, which corresponds to sand, loamy sand, sandy loam, loam, and silt loam soil groups. Prior to final site selection, in-hole permeability tests were performed by the L.K.R. Group, Inc.. The *Pre-Construction Geotechnical Evaluation Report* prepared by The L.K.R. Group, Inc., dated March 9, 1998, indicates that borings drilled at the site encountered alluvial gravels and cobbles with a fine- to course-sand matrix. The in-hole permeability rate was determined to be 1.1×10^{-3} cm/s, sufficient for the placement of an infiltration trench.

2.3 Methodology and Procedure

The estimation of the peak discharge (Q_{peak}) for a recurrence interval of a 1-year and 25-year storm event was calculated using the Rational Method, which computes the discharge as follows:

$$Q_{peak} = 0.28CiA$$

Where:

Q_{peak} = Design discharge in m^3/s
C = Coefficient of runoff
i = Average rainfall intensity in mm/hr for the selected frequency and for the duration equal to the time of concentration (t_c)
A = Drainage area in km^2

The average rainfall intensity (i) is a function of the time of concentration (t_c), and the rainfall zone in which the BMP is located. The time of concentration is defined as the time required for storm runoff to travel from the most remote point of the drainage basin to the point of interest. As given in the Caltrans Highway Design Manual, time of concentrations were calculated using the following equation:

$$t_c = \frac{3.3(1.1 - C)(L)^{1/2}}{[S(100)]^{1/3}}$$

Where:

t_c = time of concentration in minutes
C = Coefficient of runoff
L = Overland travel distance in meters
S = Slope in m/m

Table 2-1 presents the hydrologic parameters and the corresponding time of concentration for the 1-year storm event.

TABLE 2-1
TIME OF CONCENTRATIONS, 1-YEAR EVENT

Site No.	BMP Description	Runoff Coeff. C	Slope (%)	Overland travel distance (meters)	t_c (min)
1	Altadena Maintenance Station Infiltration Trench/ Biofiltration Strip	0.95	3.0	80	3.1
2	SR-91/I-605 Separation Biofiltration Strip Biofiltration Swale	 0.95 0.95	 2.0 2.0	 35 100	 2.3 3.9
3	SR-91/Cerritos Maintenance Station Biofiltration Swale	 0.95	 1.5	 100	 4.3
4	I-5/I-605 Separation Biofiltration Swale	 0.95	 1.5	 120	 4.7
5	I-605/Del Amo Biofiltration Swale	 0.95	 2.0	 50	 2.8
6	Foothill Maintenance Station StreamGuard DII Fossil Filter DII	 0.95 0.95	 3.0 3.0	 35 96	 2.0 3.4
7	Las Flores Maintenance Station StreamGuard DII Fossil Filter DII	 0.56 0.62	 2.0 2.0	 20 45	 6.3 8.4
8	Rosemead Maintenance Station Fossil Filter DII StreamGuard DII	 0.95 0.95	 2.0 2.0	 94 90	 3.8 3.7

As presented in the above table, all time of concentrations were calculated to be below the Caltrans Highway Design Manual minimum of 10 minutes. Therefore, 10 minutes was used to compute all rainfall intensities. The resulting 1-year peak discharge rates for each BMP is presented in Tables 2-2.

TABLE 2-2
PEAK DISCHARGE RATES, 1-YEAR EVENT

Site No.	BMP Description	Tributary Area Designation	Area (m^2)	Runoff Coef. C	Rainfall Intensity[1] (i) (in/hr)	Q_{peak} (m^3/s)
1 a	Altadena MS Infiltration Trench	A	6,724	0.95	0.72	0.033
1 b	Altadena MS Biofiltration Strip	A	6,724	0.95	0.72	0.033
2 a	SR-91/I-605 Separation Biofiltration Strip	A Inflow (Control)	1,896 1,816	0.95 0.95	0.32 0.32	0.004 0.004
2 b	SR-91/I-605 Separation Biofiltration Swale	A	850	0.95	0.32	0.002
3	SR-91/Cerritos MS Biofiltration Swale	A	1,760	0.95	0.32	0.004
4	I-5/I-605 Separation Biofiltration Swale	A	2,635	0.95	0.42	0.007
5	I-605/Del Amo Biofiltration Swale	A	2.796	0.95	0.32	0.006
6	Foothill MS StreamGuard DII Fossil Filter DII	A B	679 6,394	0.95 0.95	0.24 0.24	0.001 0.010
7	Las Flores MS StreamGuard DII Fossil Filter DII	A B	918 3,163	0.56 0.62	0.36 0.36	0.001 0.005
8	Rosemead MS Fossil Filter DII StreamGuard DII	A B	1,004 4,861	0.95 0.95	0.42 0.42	0.003 0.014

[1] Rainfall intensity provided by the Los Angeles County Department of Public Works for a 1-year storm event with a t_c = 10 minutes.

2.4 Summary of Results

Table 2-3 summarizes the expected peak discharges for the 1-year and 25-year storm events, the permeability rates and soil types, and the average 1-year 24-hour design storm event rainfall total.

TABLE 2-3
SUMMARY OF HYDROLOGIC DATA

Site No.	BMP Description	Design Event	Q_{peak} (m^3/s)	Ave. 1-Year, 24-Hour Storm Event Rainfall Total (in)	Permeability Rate (cm/s)	Soil Type
1a	Altadena MS Infiltration Trench	25 1	0.155 0.033	--- 1.0	1.1×10^{-3}	0 to 4.1 meters: alluvial gravels and cobbles with a fine- to course-sand matrix
1b	Altadena MS Biofiltration Strip	25 1	0.155 0.033	--- N/A	N/A	0 to 4.1 meters: alluvial gravels and cobbles with a fine- to course-sand matrix
2a	SR-91/I-605 Separation Biofiltration Strip	25 1	0.039 0.004	--- N/A	1.6×10^{-4}	surface mulch and tree cuttings
	Inflow controlled	25 1	0.037 0.004	--- N/A	1.6×10^{-4}	
2b	SR-91/I-605 Separation Biofiltration Swale	25 1	0.018 0.002	--- N/A	N/A	surface mulch and tree cuttings
3	SR-91/Cerritos MS Biofiltration Swale	25 1	0.036 0.004	--- N/A	N/A	0 to 0.9 meters: fill with alluvial fine- to medium grained sand with silt and minor fractions of clay below 3.0 meters
4	I-5/I-605 Separation Biofiltration Swale	25 1	0.054 0.007	--- N/A	N/A	medium- to course grained sands and interbeds of fine-grained sands, silty sands, and silts
5	I-605/Del Amo Biofiltration Swale	25 1	0.058 0.006	--- N/A	N/A	Fill sough
6	Foothill MS StreamGuard DII	25 1	0.016 0.001	--- N/A	N/A	Cobbles and alluvial gravels with fine- to course-grained sand matrix
	Fossil Filter DII	25 1	0.148 0.010	--- N/A		
7	Las Flores MS StreamGuard DII	25 1	0.013 0.001	--- N/A	N/A	no data available
	Fossil Filter DII	25 1	0.051 0.005	--- N/A		
8	Rosemead MS Fossil Filter DII	25 1	0.023 0.003	--- N/A	N/A	no data available
	StreamGuard DII	25 1	0.112 0.014	--- N/A		

3.0 WATER QUALITY DESIGN DISCUSSION AND ASSUMPTIONS

Technical references used for BMP water quality design include the *Caltrans Highway Design Manual* (Caltrans 1997), *the Caltrans Storm Water Quality Handbook, Planning and Design Staff Guide* (Caltrans 1997), *Evaluation and Management of Highway Runoff Water Quality* (U.S. Dept. of Transportation FHWA, 1996), *Biofiltration Swale Performance, Recommendations, and Design Considerations* (Municipality of Metropolitan Seattle, Water Polution Control Department, 1992), *Draft Surface Water Design Manual* (King County Washington 1995), *Composite Siting Study, District 7* (Robert Bein, William Frost and Associates 1998), and *Scoping Study, Retrofit Pilot Program, Caltrans District 7* (Robert Bein, William Frost and Associates 1998).

3.1 Site 1, Altadena Maintenance Station (Biofiltration Strip & Infiltration Trench)

3.1.1 Design Summary

This maintenance station is the proposed site for a biofiltration strip and infiltration trench. The biofiltration strip will be located upstream of the infiltration trench to act as a pretreatment device to increase the water quality of the runoff prior to infiltration into the soil and to minimize the amount of sedimentation entering the trench.

The existing grading at the maintenance station does not provide natural sheet flow for the biofiltration strip. Therefore, the runoff will first be collected in a concrete valley gutter, then passed through an h-flume, then collected in a concrete spreader ditch to distribute the runoff across the length of the strip. The H-flume will be used to measure influent flow characteristics.

The biofiltration strip is 8 meters in length by 20 meters wide, set at a slope of 3%. The dimensions were restricted by available space, as is presented in section 3.1.3 below. The Biofiltration Strip will be vegetated with a specific mix selected by Caltrans' vegetation consultant (see Appendix D).

Flow from the biofiltration strip is collected and measured by an inline H-flume before being distributed into the infiltration trench. The runoff enters the trench in the northwest corner, directly behind the h-flume. The fill material in the infiltration trench has sufficient voids that allows the inflow to first flow into and fill the trench, much like an underground tank. The surrounding soil requires a greater head loss for the water to flow through it and therefore the trench will fill before any "short circuiting" could occur. Once the trench is full, overflow is allowed at the overflow structure to the existing drain outlet. The trench will also be lined with a geotextile filter fabric and include an observation well and lysimeter for monitoring purposes.

A depressed curb will be placed around the biofiltration strip and infiltration trench to prevent runoff from entering the BMPs along the perimeter.

3.1.2 Tributary Drainage Area

The tributary drainage area for the biofiltration strip and infiltration trench is 6,724 square meters. The area includes runoff from parked maintenance vehicles, a fueling station, maintenance garage, and vehicle wash area. The runoff begins at the north corner of the maintenance station, and is currently directed to a curb gutter located between the vehicle maintenance building and an open storage area. A valley gutter will be placed upstream of the biofiltration strip to direct as much runoff as possible to the BMP site. The 1 year, 24 hour peak flow is 0.033 cubic meters per second.

3.1.3 Siting Constraints

The location and design of the biofiltration strip and infiltration trench were restricted due to available space within the maintenance station property. The maintenance staff utilizes the entire footprint of the maintenance station, and the BMPs had to be sized and located to minimize the impact on existing operations. The existing curb gutter is located between a vehicle wash area and six open concrete storage bays. The wash area is at an elevation 1.0 meter higher than the curb gutter. The one side of the BMPs was therefore located at the bottom of the slope to prevent the need for a retaining wall. The other end was restricted by the storage bays, which must stay in the general vicinity of where they currently are because there is no other place to put them. Of the six bays, it was determined that three could be relocated (within the same area) without significantly affecting maintenance station operations. The resulting distance between the bottom of the wash area slope and the storage bays was increase from 7.5 meters to 20 meters. The width of the biofiltration strip was then set to 20 meters.

The length of the biofiltration strip was also restricted by available space, but was set to 8 meters which is the minimum length specified in the *Scoping Study* (8 meters). Increasing the length would extend the strip into a traffic area, which was not possible. As a result of these constraints, the anticipated residence time for the 1 year peak flow is 2 minutes (see Appendix B for details). In order to achieve a residence time of 5 minutes, the biofiltration strip would need to be 60 meters wide by 12 meters long, which is not available at this site.

Site constraints were not as limiting for the infiltration trench, and the design includes a trench large enough to store the 1 year volume of runoff. The infiltration trench will be located behind the storage bays, in an area not frequently used by maintenance station staff. However, there was not enough space to have the runoff entering the trench along its entire width after it passed through the h-flume. This is not expected to pose a problem, as is discussed in Section 3.1.1 above.

A 1.8 meter high fence will be placed around the entire BMP area, in response to maintenance staff concerns over bumping into or tripping over the BMP at night when the area is not well lit.

3.2 Site 2, SR-91/I-605 Separation (Biofiltration Strip and Biofiltration Swale)

3.2.1 Design Summary

This open area bounded by three roadways (the Eastbound SR-91 / Northbound I-605 connector, the Northbound I-605 / Westbound SR-91 connector, and the Westbound SR-91 / Southbound I-605 connector) is well suited for a number of BMPs, and was selected to be the site for a biofiltration strip and a biofiltration swale (operating separately and treating distinct tributary areas). The biolfiltration strip will treat runoff from the northbound lanes of I-605 and a portion of the Eastbound SR-91 / Northbound I-605 connector, while the biofiltration swale will treat the runoff from the Westbound SR-91 / Southbound I-605 connector (the runoff from the Northbound I-605 / Westbound SR-91 connector is already being treated by an Infiltration Basin in the adjacent cloverleaf connector). Both the biofiltration strip and biofiltration swale will be covered with a BMP seed mix selected for this project (see Appendix D).

For the biofiltration strip, there are two down drains located along the shoulder of the Eastbound SR-91 / Northbound I-605 connector which drain into the open area. The one located further north will be used as a control location, monitoring the water quality of similar untreated runoff. This will provide a mechanism for determining the effectiveness of the BMP. The other advantage to this approach is that the runoff which currently flows down the other down drain can flow directly onto the strip from the roadway without requiring an artificial flow spreader. An h-flume will be placed at this northern down drain.

The strip will be graded at a 2% slope, with dimensions of 8 meters long by 60 meters wide. The embankments of the two connectors prevent the strip from being any larger. However, the strip as designed will have a residence time of 8 minutes for the 1 year runoff event. The existing asphalt concrete dike along the shoulder will be removed to allow the runoff to flow across the strip. A concrete lined collection ditch at the end of the strip is provided to convey flow to an h-flume for monitoring post-treatment flow and water quality.

For the biofiltration swale, an energy dissipator will be located at the headwall followed by an h-flume to monitor pre-treated flow characteristics. A 40 meter swale then follows, which has the shape of a trapezoidal channel with a bottom channel width of 1.5 meters and a channel height of 0.3 meters. A concrete sump will be placed between the upstream flume and the swale to act as a flow spreader device to uniformly spread the flow across the width of the swale. Downstream of the swale is a second h-flume. The runoff then follows its natural path to the existing outlet. The calculated residence time for the 1 year runoff event is 12 minutes.

3.2.2 Tributary Drainage Area

The biofiltration strip receives runoff from the northbound lanes of I-605 and the last 50 meters of the Eastbound SR-91 / Northbound I-605 Connector. The total tributary drainage area is equal to 1,896 square meters. This area is bounded by two overside drains along the northbound shoulder and the median separating the northbound and southbound lanes. The peak flow for the 1 year, 24 hour event is 0.004 cubic meters per second (0.14 cfs).

The biofiltration swale receives runoff from the Westbound SR-91 / Southbound I-605 Connector and totals 850 square meters. The area is bounded by the down drain leading to the swale and high point on the connector as it passes over I-605. The peak flow for the 1 year, 24 hour event is 0.002 cubic meters per second (0.06 cfs).

3.2.3 Siting Constraints

The only direct access to the biofiltration strip site is from the roadway shoulder, thereby making it necessary to construct an asphalt concrete maintenance pullout. Furthermore, District policy requires that the pullout must be long enough to provide a parked vehicle with adequate distance to accelerate to a sufficient speed before merging into traffic. This resulted in a 95 meter long pullout, which covers the entire shoulder along the open area in question. This prevented the strip from being located adjacent to the shoulder, and it will therefore be located adjacent to the pullout (which slightly increased the tributary drainage area being treated since the pullout also drains into the strip). The pullout will also require relocation of a light pole and a drain inlet. For vehicle safety, District 7 also requires the placement of crash cushion arrays in front of monitoring equipment.

Given that the swale is located away from the roadway, it was not required to include any safety devices in the design. Access to the site will be accomplished from the pullout being built for the adjacent biofiltration strip.

3.3 Site 3, SR-91 / Cerritos Maintenance Station (Biofiltration Swale)

3.3.1 Design Summary

This location was identified as the site for a biofiltration swale, which will treat runoff from the westbound lanes of Route SR-91. Currently, the runoff in question is captured along the shoulder of the roadway by a drain inlet, which is then discharged at the bottom of an embankment through a corrugated metal pipe. An asphalt V-ditch directs the runoff westward, where it is eventually combined with runoff from the Cerritos Maintenance Station and runoff from the embankment located behind the maintenance station (from the Northbound I-605 / Westbound SR-91 connector), before discharging through a headwall and into a cloverleaf connector (which is the site for an infiltration basin; refer to Report CTSW-RT-98-55, Basis of Design Report, Drainage Design, District 7 PS&E).

The biofiltration swale will be1.5 meters wide by 20 meters long with a longitudinal slope of 2%. The design includes an energy dissipator at the outlet of the corrugated metal pipe, H-flumes at the upstream and downstream ends of the swale to monitor flow characteristics, and a concrete sump between the upstream h-flume and the swale to provide uniform flow across the width of the swale. The anticipated hydraulic residence time for the 1-year runoff event is 4.6 minutes. This time is slightly below the minimum recommended time of 5 minutes, but was the maximum time possible given specific site constraints (see Section 3.3.2). The swale is designed to prevent runoff from entering the swale along its length. The biofiltration swale will be covered with a special BMP seed mix selected for this project (see Appendix D).

Access to the site will be accomplished from a gate located along the southern fence of the maintenance station. Also due to the close proximity of the Caltrans facility, electric power for the refrigerated samplers will be obtained from the maintenance station.

3.3.2 Tributary Drainage Area

The tributary drainage area for this BMP is 1,760 square meters, and comes from a 100 meter long section of the Westbound SR-91. The area is bounded by the down drain leading to the swale, a concrete gutter separating the roadway from the merging lane of the Northbound I-605 / Westbound SR-91 connector, and the median between the Westbound and Eastbound lanes of SR-91. Given the available space for the biofiltration swale it was determined to be inappropriate to attempt to capture and treat any additional runoff. The peak flow for the 1 year, 24 hour event is 0.004 cubic meters per second (0.13 cfs).

3.3.3 Siting Constraints

The design of the biofiltration swale is restricted by the available area and topography of the site. The distance between the end of the existing downdrain pipe and the outlet headwall is approximately 30 meters. Furthermore, the existing v-ditch, along with the maintenance station, is prone to flooding during heavy rainfalls due to the relatively flat slope in the area (the entire v-ditch between the headwall and the endwall was flooded at least on one occasion following a heavy rainfall in 1998). To prevent the swale from flooding, it will be raised at the upstream end. This will require the runoff to be captured at a point higher than where it currently exits the corrugated metal pipe. The downstream end is being located approximately 3 meters upstream of the point where its runoff combines with the two other v-ditch channel flows. This then shortened the possible swale length by 3 meters (which would have added another 45 seconds of residence time).

The H-flumes at the swale inlet and outlet require approximately 2.5 meters each, thereby reducing the available length to 23 meters. Energy dissipators at the ends of the H-flumes require 2 meters. All these additional improvements result in 20 meters left for the swale, which was the length utilized in the design. In order to obtain a 9 minute residence time, the swale length would need to be 40 meters. This could only be achieved by capturing the runoff at a higher point along the embankment, then re-directed eastward toward Studebaker Road then westward into the swale. The construction of this diversion was determined to be inappropriate for this BMP.

3.4 Site 4, I-5/I-605 Separation (Biofiltration Swale)

3.4.1 Design Summary

This location is an open area along the Southbound shoulder of Route I-5 between the Southbound I-5 / Southbound I-605 connector and the I-605 overcrossing. The runoff from the Southbound lanes of I-5 travels along an asphalt-concrete dike, then down an overside drain, and into a fairly dense area of trees and brush. Natural contours of the open area cause the runoff to eventually discharge into a concrete drain located at the low point in the open area. A biofiltration swale will be constructed along these natural contours. However, it should be noted that the layout of the open area and space available make this site suitable for other types of BMPs as well.

The dimensions of the swale are set to 2 meters wide by 40 meters long, with side walls at a 2:1 slope. This will provide a residence time of 7.9 minutes for the 1-year runoff event. Other design features include H-flumes at the inlet and outlet of the swale for monitoring, an energy dissipator at the outlet of the overside drain, and a concrete sump spreader to distribute the flow evenly across the width of the swale. The side walls will be built up and graded to prevent additional runoff from entering the swale along it length (and thereby distorting the data for measuring the efficiency of the BMP). The natural contours of the area were used to lay out the swale to minimize re-grading. Following the BMP improvements, the runoff is discharged along the ground, where the natural contours will direct the runoff to its original destination. The biofiltration swale will be covered with a special BMP seed mix selected for this project (see Appendix D).

3.4.2 Tributary Drainage Area

The tributary area of the site is a 300 meter long section of the Southbound lanes of Route I-5, and has a total area of 2,635 square meters. The drainage area is bounded by the down drain leading to the BMP, the Southbound I-5 / Southbound I-605 Connector, and the median between the Southbound and Northbound lanes of I-5. The peak flow for the 1 year, 24 hour event is 0.007 cubic meters per second (0.26 cfs). Collecting additional runoff from the Southbound I-5 / Southbound I-605 Connector which does not currently drain to the BMP site would require a jacking pit, receiving pit, boring hole, two headwalls, fill export, and approximately 20 meters of 600 mm RCP pipe. The tributary drainage area from the connector is less than 2,000 square meters.

3.4.3 Siting Constraints

The dense brush (including a rather large palm tree) will have to be thinned out to make room for the energy dissipator and H-flume. However, the amount of brush to be removed will be kept to a minimum to respond to Caltrans concerns over preservation of existing landscaping. Other than this brush, the area of construction is fairly flat and open.

Given the location of the site (bounded by interstate freeways and freeway connectors) the only access to the site is from the shoulder. As a result, Caltrans District 7 requires an asphalt-concrete maintenance pullout, including an extended exit taper to provide the motorist enough distance to safely merge back into the roadway. Fortunately, the slope of the embankment is not steep, and a retaining wall is not necessary. The existing dike along the length of the pullout will be removed and a new Type E asphalt-concrete dike will be placed along the backside. There are a number of utilities that will have to be relocated due to the pullout, including a call box, part of the irrigation system, and some sprinkler heads.

Also due to the isolated nature of the site, batteries will be utilized to provide electric power.

3.5 Site 5, I-605 / Del Amo (Biofiltration Swale)

3.5.1 Design Summary

The fourth biofiltration swale site is located along the shoulder of the Northbound I-605 between Carson Street and Del Amo Boulevard. Between these two offramps (located approximately 1.5 km apart) are a series of down drains, which transport runoff from the northbound lanes of the roadway along a 10 meter wide embankment which is bounded by a sound wall. The down drains located north of the Centralia bridge overcrossing direct the runoff to a concrete drain, which transports the runoff under the freeway. The embankment currently functions as a natural biofiltration swale, bounded by the asphalt concrete dike of the roadway and the soundwall, covered with Ice Plant and various bushes and trees. The brush is dense at certain places, and minimal at others.

The dimensions of the swale are set to 54 meters in length by 1 meter in width with side walls at a 2:1 slope. The longitudinal slope of the swale will be 2.0%, and the design prevents additional runoff from entering the swale along its length. The resulting residence time for the 1 year runoff event is 9.0 minutes. H-flumes will be utilized at the upstream and downstream ends of the swale to monitor the flow, and energy dissipators will be located at both ends of the BMP. A concrete sump structure will be located between the upstream h-flume and the swale inlet to spread the runoff evenly across the swale. As with the previous biofiltration swales, this one includes the same BMP seed mix to promote pollutant removal.

3.5.2 Tributary Drainage Area

Although the tributary area of all down drains located between Carson Street and Del Amo Boulevard totals over 30,000 square meters, the entire area could not be treated because it would require the removal of a significant amount of landscaping. Therefore, the biofiltration swale will treat the runoff from a single down drain which is located approximately 100 meters north of the Centralia overcrossing. This area equals 2,796 square meters, and is bounded by two down drains and the median between the Northbound and Southbound lanes of I-605. The peak flow for the 1 year, 24 hour event is 0.006 cubic meters per second (0.21 cfs).

If it was desirable to treat additional runoff at this site, the BMP could be modified. First of all, if the slope of the Biofiltration Swale were reduced to 1 percent, the swale length could be increased to approximately 110 m (as opposed to the current 54 m). The length could not be increased while maintaining the current 2-percent slope because this is steeper than the existing grade. By increasing the length to 110 m, the runoff associated with the adjacent tributary area to the north could also be treated, increasing the total treated area from 2,796 m^2 to approximately 4,200 m^2. Hydraulic calculations for this scenario resulted in a depth of flow of 84 mm and an average hydraulic residence time of over 17 minutes.

To provide treatment for even more runoff, the asphalt-concrete dike in front of the Biofiltration Swale along the roadway shoulder could be removed, allowing runoff to enter the swale along its length. This option was not included in the original design for monitoring reasons, since the downstream samples would represent runoff of varying degrees of treatment. However, maximizing the amount of runoff to be treated is desired, this modification could be performed. Doing so would provide limited treatment for an additional 2,000 m^2 of tributary area.

The cost to redirect the above mentioned additional flow to the I-605/Del Amo Biofiltration Swale would be approximately $61,000. A detailed cost estimate is provided in Table 3-1.

TABLE 3-1
ADDITIONAL TREATMENT COST – I-605/DEL AMO BIO. SWALE

Item	Description	Qty	Unit	Unit $	Cost
1	Asphalt Concrete (Type B)	2	TONN	$142	$284
2	150 mm Perforated Pipe	75	M	$119	$8,925
3	Import Borrow	40	M3	$26	$1,040
4	Metal Beam Guard Railing	55	M	$119	$6,545
5	Minor Concrete	14	M3	$949	$13,286
6	Place AC Dike	-70	M	$47	($3,290)
7	Remove Asphalt Concrete Dike	1	M	$12	$12
8	Underdrain Backfill Rock	5	M3	$593	$2,965
9	Underdrain Filter Fabric	90	M2	$83	$7,470
10	Seed (Erosion Control & BMP)	1	LS	$11,800	$11,800
11	Grading/Excavation/Fill	1	LS	$2,372	$2,372
12	Temporary Railing (Type k)	60	M	$42	$2,520
13	Biofiltration Swale	1	LS	$949	$949
14	Clearing and Grubbing	1	LS	$2,372	$2,372
15	Relocate Irrigation Line	1	LS	$3,500	$3,500
	Total Cost				**$60,750.00**

The above cost assumes the following:

- A perforated underdrain is installed beneath the Biofiltration Swale due to the longitudinal slope of 1 percent.
- Metal Beam Guard Railing is extended to cover the entire length
- Existing Irrigation facilities in the area of the extended swale are relocated
- The work is performed during the construction of the Biofiltration Swale (to avoid additional mobilization and traffic control expenses).
- The contract unit prices for the Biofiltration Swale construction apply to this additional work.

3.5.3 Siting Constraints

Factors considered when selecting the exact location for the swale included close proximity to a down drain to minimize the cost of constructing a transport system, and minimizing the removal of existing landscape (a concern of various Caltrans District 7 staff). After evaluating various potential sections of the shoulder, it was decided to locate the swale directly upstream of the Centralia bridge overcrossing. There is a down drain approximately 90 meters north of the concrete drain, and the brush is minimal. The swale is also placed near the roadway shoulder and away from the sound wall and natural flow line to allow upstream runoff to bypass the swale.

Extending the swale closer either northward or southward in order to treat more runoff as sheet flow was evaluated, but was rejected for several reasons. To the north are a number of bushes and trees, which would either have to be removed or the swale would have to zig-zag around them. To the south are other components of the BMP, such as metal beam guard rail, a maintenance pullout, and an equipment housing pad. Furthermore, by allowing additional runoff to flow onto the swale along its length would make it extremely difficult to estimate the efficiency of the swale because the samples taken downstream of the swale would contain runoff with little or no treatment. For these reasons the swale was not extended to provide treatment of runoff other than the overside drain at the swale inlet. However, this could be done if necessary, and the costs to do so are presented in Section 3.5.2.

Site access is limited to the roadway shoulder, thereby necessitating a maintenance pullout. The length of the pullout is 110 meters long, in accordance with District requirements. District 7 also required that the instrument housings be protected from motorist accidents. A metal beam guard rail was therefore placed in front of the swale behind the pullout. One tree will have to be removed to make room for the metal beam guard rail. Although it was initially desirable to provide power from a nearby utility pole behind the sound wall, further investigations revealed that the nearest pole was at least 50 meters away, creating a costly expense. It was therefore decided that batteries would be utilized for the sampling equipment.

3.6 Site 6, Foothill Maintenance Station (Drain Inlet Inserts)

3.6.1 Design Summary

Foothill Maintenance Station in Altadena is the site for retrofitting drain inlets with Drain Inlet Inserts. The two drain inlets identified in the *Siting Study* will be retrofitted with the Fossil Filter and Streamguard inserts.

The runoff exiting the retrofitted inlets will pass through a Palmer-Bowlus flume which is built into a standard Caltrans G2M inlet. The flume will be located at least 20 pipe diameters downstream of the inlets to establish uniform flow. Plastic pipes will be used to prevent possible contamination of the sample. All new plastic pipe will be the same diameter as the pipe being replaced.

The northern inlet will be retrofitted with the StreamGuard insert, and the southern inlet will be retrofitted with the Fossil Filter insert.

Rain gauges will also be installed at the site to monitor accumulated rainfall and track when the inserts must be replaced (in accordance with the guidelines presented in the Scoping Study). Reliable electric power is readily available. This will enable the use of refrigerated samplers and avoid the need for batteries.

3.6.2 Tributary Drainage Area

Although the Siting Study estimated the two tributary areas to be of similar characteristics, the actual tributary areas are 679 m^2 and 6,394 m^2, respectively. The northern drain inlet (679 m^2) is located in the northeast corner of the maintenance station and receives runoff primarily from a small parking lot for employees. The southern drain inlet receives runoff from a number of operations-related facilities. The peak flows for the 1 year, 24 hour event is 0.001 cubic meters per second (0.04 cfs) and 0.010 cubic meters per second (0.37 cfs) for the northern and southern inlets, respectively.

3.6.3 Siting Constraints

The design of the site is fairly straightforward with one notable exception. The southern drain inlet receives runoff from an upstream drain inlet in addition to the runoff entering from the pavement. In order to isolate the desired pavement runoff, the runoff from the upstream inlet will be re-routed around the retrofitted inlet. This modification will be accomplished using standard Caltrans G2M inlets. The re-routed runoff will be re-joined with the runoff exiting the retrofitted inlet at least 5 pipe diameters downstream of the flume to prevent backwater conditions. In response to Caltrans' concerns over safety, guard posts will be located around the equipment housing pads.

3.7 Site 7, Las Flores Maintenance Station (Drain Inlet Inserts)

3.7.1 Design Summary

Las Flores Maintenance Station, located just north of Malibu, is the second of three Drain Inlet Insert sites. The maintenance station was just recently re-constructed, as a result of damaged sustained in a recent fire. Two drain inlets operating in series, transport the runoff from the station into a clarifier tank.

The design at Las Flores follows the same approach that was employed at Foothill Maintenance Station. Palmer-Bowlus flumes will be installed in G2M Inlets located at least 20 pipe diameters downstream of the drain inlet for monitoring purposes. Plastic pipe will be used for all retrofit activities, maintaining the same diameter as the pipe being replaced. Equipment housing pads will be surrounded with guardposts for safety, and a rain gauge will be installed to monitor rainfall. Electricity to power the refrigerated samplers will be obtained from the maintenance station.

The northern inlet will be retrofitted with the StreamGuard insert, while the southern inlet will be retrofitted with the Fossil Filter insert.

3.7.2 Tributary Drainage Area

At this site, the two drain inlets will receive runoff of similar characteristics. The northern inlet has a tributary area of 918 m^2, while the southern inlet has a tributary area of 3,163 m^2. One notable difference between this site and other maintenance stations is that a significant portion of the tributary area comes from a hillside located along the western edge of the maintenance station. This has a direct impact on the flow since the coefficient of runoff for non-paved areas is lower than paved areas. The peak flows for the 1 year, 24 hour event are 0.001 cubic meters per second (0.05 cfs) and 0.005 cubic meters per second (0.18 cfs) for the northern and southern inlets, respectively.

3.7.3 Siting Constraints

Both drain inlets at this site receive runoff from additional sources besides what enters through the grate. This is undesirable because the runoff entering the monitoring equipment downstream of the inlet would contain runoff that did not flow through the insert. At the northern inlet, a storm drain manhole discharges into the inlet. Following retrofit, this flow will bypass the drain inlet and then be re-joined downstream of the monitoring flume using G2M inlets. The southern inlet receives runoff from the northern inlet (and therefore the storm drain manhole also) and from a vehicle wash rack. The flow from the northern inlet will be intercepted upstream of the retrofitted drain inlet with a G2M inlet and re-joined prior to discharge into the clarifier tank. The runoff from the wash rack will be re-directed to the G2M inlet intercepting the upstream flow.

3.8 Site 8, Rosemead Maintenance Station (Drain Inlet Inserts)

3.8.1 Design Summary

Rosemead Maintenance Station is the third and Drain Inlet Insert site in the pilot program. The design at this site reflects the following approach. The northern drain inlet receives runoff from the grate only, and therefore can be retrofitted without any re-piping. The Palmer-Bowlus monitoring flume will be placed in a G2M inlet and located at least 20 pipe diameters downstream of the inlet. The RCP pipe between the inlet and the flume will be replaced with a plastic pipe of the same diameter (450 mm). The pipe exiting the flume, which discharges into the southern inlet, will remain as-is.

The Drain Inlet Inserts will be placed using a contrasting strategy to what was implemented at Foothill Maintenance Station. At this site, the Fossil Filter insert will be placed in the northern inlet, and the StreamGuard insert will be placed in the southern inlet. Therefore, at the two Drain Inlet Insert sites which have one drain inlet receiving a greater runoff volume, the Fossil Filter insert will be placed in the drain inlet receiving the greater runoff at one maintenance station, and in the drain inlet receiving the lesser runoff at the other maintenance station.

A rain gauge will be installed near the northern inlet to monitor rainfall, and guard posts will be placed around the northern equipment housing for safety. Guard posts are not needed at the southern end because the equipment housing will be located between the curb and the property fence.

3.8.2 Tributary Drainage Area

The northern drain inlet at this site has a tributary area of 1,004 m^2.and receives runoff from area between the maintenance building and the back fence. The southern drain inlet has a tributary area of 4,861 m^2, and receives runoff from a significant portion of the maintenance station. The peak flows for the 1 year, 24 hour event are 0.003 cubic meters per second (0.10 cfs) and 0.014 cubic meters per second (0.49 cfs) for the northern and southern inlets, respectively.

3.8.3 Siting Constraints

The retrofit of the southern inlet is not as straightforward because the existing inlet is a curb inlet. The construction here entails covering the curb inlet with a steel plate and placing a new G2 inlet next to it. By covering the curb inlet, the internal piping will remain undisturbed, and the runoff will be allowed to pass through the structure as it does now. The Drain Inlet insert will be placed in a new G2 inlet, and the surrounding area will be re-graded to ensure that the new inlet is located at the low point. The runoff exiting the retrofitted inlet will pass through a modified G2 inlet fitted with a Palmer-Bowlus flume, then a junction box (another G2 inlet) to bring the flow back to its original discharge point behind the curb inlet. These improvements can not be done in parallel (ie, inline) to the original flow path because there is not enough room between the curb inlet and the property fence. Therefore, the runoff will be directed westward for monitoring, and then brought back.

4.0 HYDRAULIC ANALYSIS

4.1 Design Criteria

This section will address the hydraulic performance of the BMP Retrofit Pilot Facilities during the critical runoff event of a 25 year storm as determined in the *Caltrans Highway Design Manual* (Caltrans 1997*)*. Other technical references used include the *Caltrans Storm Water Quality Handbook*, *Planning and Design Staff Guide* (Caltrans *1997), Biofiltration for Stormwater Quality Control, Course Manual* (R. Horner 1996), *Foss Environmental Product Guide* (Foss Environmental Spring 1998), *Fossil Filter Manual* (KriStar Enterprises, Inc. 1996), and the *Scoping Study, Retrofit Pilot Program* , *Caltrans District 7 (*Robert Bein, et al. April 28, 1998*)*. The critical runoff event frequency designated in the *Caltrans Highway Design Manual* is for a storm with a return period of 25 years. Therefore, the runoff from a 25 year storm event was used for the critical event in checking the capacity of the BMP Retrofit Facilities.

Calculations for the biofiltration strips and biofiltration swales for the 25 year event are provided in Appendix C.

4.2 Methodology and Design Procedures

The effect of the 25-year critical storm event on the BMP Retrofit facilities was determined with respect to the increase in runoff velocity and the decrease in residence time. Of particular concern were the flow velocities generated by the critical storm event. The velocities and residence times were calculated by using Mannings formula to compute depths of flow and subsequently using the continuity equation to determine velocity. Detention time, or residence time, then became a function of length and velocity. In all cases, the velocities for the critical event were less than 0.27 meters per second and therefore less than the magnitude that would cause excessive erosion.

The peak flows for the 25 year event were calculated using the same procedures are presented in Section 2 for the 1 year event. Note that the only difference in the calculation for the two recurrence intervals is the coefficient of runoff, C. As explained in the Caltrans Highway Design Manual, infiltration, detention, and other losses have a proportionally smaller effect during less frequent, higher intensity storms. As given in the manual, the effect was accounted for by multiplying the runoff coefficient by a frequency factor of 1.1. The resulting product was then used, unless the product was greater than 1.0, in which case a value of 1.0 was used. The estimated time of concentrations for each BMP is presented in Table 4-1.

TABLE 4-1
TIME OF CONCENTRATIONS, 25-YEAR EVENT

Site No.	BMP Description	Runoff Coeff. C	Slope (%)	Overland travel distance (meters)	t_c (min)
1	Altadena Maintenance Station Infiltration Trench/ Biofiltration Strip	1.00	3.0	80	2.0
2	SR-91/I-605 Separation				
	Biofiltration Strip	1.00	2.0	35	1.5
	Biofiltration Swale	1.00	2.0	100	2.6
3	SR-91/Cerritos Maintenance Station				
	Biofiltration Swale	1.00	1.5	100	2.9
4	I-5/I-605 Separation				
	Biofiltration Swale	1.00	1.5	120	3.2
5	I-605/Del Amo				
	Biofiltration Swale	1.00	2.0	50	1.9
6	Foothill Maintenance Station				
	StreamGuard DII	1.00	3.0	35	1.4
	Fossil Filter DII	1.00	3.0	96	2.2
7	Las Flores Maintenance Station				
	StreamGuard DII	0.62	2.0	20	5.6
	Fossil Filter DII	0.70	2.0	45	7.0
8	Rosemead Maintenance Station				
	Fossil Filter DII	1.00	2.0	94	2.5
	StreamGuard DII	1.00	2.0	90	2.5

As shown, all time of concentrations were calculated to be below the Caltrans Highway Design Manual minimum of 10 minutes. Therefore, 10 minutes was used to compute all rainfall intensities. For the 25 year storm event, the standard Caltrans average intensity duration curves were utilized. The eight BMP sites are grouped between the Los Angeles Coastal Plain (Region K) rainfall zone and the Los Angeles Interior Valley (Region L) rainfall zone. Refer to Appendix A for further information. Using these pre-determined zones and the Caltrans District 7 average intensity duration curves for a 25 year storm event, the desired rainfall intensities were computed. The rainfall intensities and the resulting peak discharge rates are presented in Table 4-2.

TABLE 4-2
PEAK DISCHARGE RATES, 25-YEAR EVENT

Site No.	BMP Description	Tributary Area Designation	Area (m^2)	Runoff Coef. C	Rainfall Intensity[1] (i) (in/hr)	Q_{peak} (m^3/s)
1a	Altadena MS Infiltration Trench	A	6,724	1.00	3.25	0.155
1b	Altadena MS Biofiltration Strip	A	6,724	1.00	3.25	0.155
2a	SR-91/I-605 Separation Biofiltration Strip	A	1,896	1.00	2.90	0.039
		Inflow (Control)	1,816	1.00	2.90	0.037
2b	SR-91/I-605 Separation Biofiltration Swale	A	850	1.00	2.90	0.018
3	SR-91/Cerritos MS Biofiltration Swale	A	1,760	1.00	2.90	0.036
4	I-5/I-605 Separation Biofiltration Swale	A	2,635	1.00	2.90	0.054
5	I-605/Del Amo Biofiltration Swale	A	2.796	1.00	2.90	0.058
6	Foothill MS					
	StreamGuard DII	A	679	1.00	3.25	0.016
	Fossil Filter DII	B	6,394	1.00	3.25	0.148
7	Las Flores MS					
	StreamGuard DII	A	918	0.62	3.25	0.013
	Fossil Filter DII	B	3,163	0.70	3.25	0.051
8	Rosemead MS					
	Fossil Filter DII	A	1,004	1.00	3.25	0.023
	StreamGuard DII	B	4,861	1.00	3.25	0.112

[1] Rainfall intensity from Caltrans District 7 Average Intensity Duration Curves for a 25-year storm event with a t_c </= 10 minutes.

The Palmer-Bowlus flumes and H-flumes were sized based on the expected range of flow rates. The capacities of the selected flumes along with the expected flows are presented in Table 4-3. In all cases, the water quality peak flow (from the 1-year event) exceeds the minimum flume capacity. In most cases, the flumes will also handle the 25-year event. However, in some instances the peak 25-year flow may exceed the maximum capacity of the flume.

TABLE 4-3
MONITORING FLUME HYDRAULIC CAPACITIES

Site No.	BMP Description	Flume Type	Flume Size (m)	Q_{peak} 1-year (m^3/s)	Q_{peak} 25-year (m^3/s)	Min Flume Capacity (m^3/s)	Max Flume Capacity (m^3/s)
1a	Altadena Maintenance Station Biofiltration Strip	H	0.457	0.033	0.155	2.5E-05	0.152
1b	Altadena Maintenance Station Infiltration Trench		N/A	0.033	0.155	N/A	N/A
2a	SR-91/I-605 Separation Biofiltration Strip	H	0.305	0.004	0.039	1.6E-05	0.054
2b	SR-91/I-605 Separation Biofiltration Swale	H	0.229	0.002	0.018	1.4E-05	0.026
3	SR-91 / Cerritos M.S. Biofiltration Swale	H	0.305	0.004	0.036	1.6E-05	0.054
4	I-5/I-605 Separation Biofiltration Swale	H	0.305	0.007	0.054	1.6E-05	0.054
5	I-605/Del Amo Biofiltration Swale	H	0.305	0.006	0.058	1.6E-05	0.054
6	Foothill Maintenance Station						
a	StreamGuard DII	Palmer-Bowlus	0.203	0.001	0.016	7.4E-04	0.019
b	Fossil Filter DII	Palmer-Bowlus	0.457	0.010	0.148	4.6E-03	0.131
7	Las Flores Maintenance Station						
a	StreamGuard DII	Palmer-Bowlus	0.203	0.001	0.013	7.4E-04	0.019
b	Fossil Filter DII	Palmer-Bowlus	0.305	0.005	0.051	1.8E-03	0.048
8	Rosemead Maintenance Station						
a	Fossil Filter DII	Palmer-Bowlus	0.254	0.003	0.023	1.6E-03	0.031
b	StreamGuard DII	Palmer-Bowlus	0.381	0.014	0.112	3.4E-03	0.088

A summary of the hydraulic operational characteristics of each BMP type follows.

4.2.1 Infiltration Trench

As discussed in Section 3, the infiltration trench is designed to capture the water quality event (1 year storm), which is 1 inch of rainfall. During less frequent, higher intensity storms, the runoff will continue to enter the trench. However, an overflow device is provided in the trench design and is located adjacent to the existing concrete drain which discharges into the existing outlet concrete channel. The overflow has the same dimensions as the existing outlet, and therefore will not create any additional hazards. Once the trench fills up, any excess runoff will overflow as designed.

4.2.2 Biofiltration Strips

As presented in Appendix B, the 25 year storm will significantly increase the velocity and depth of flow across the strips. The depth of flow will increase to 67 mm and 15 mm at Altadena Maintenance Station and the SR-91/I-605 Separation, respectively. At the maintenance station, a 25 mm depressed curb will surround the biofiltration strip on the one exposed side (the other side is up against the storage bay walls). Therefore, the critical runoff flow may overflow the curb. If this occurs, the runoff will travel along the existing drainage patterns along the toe of slope adjacent to the wash area and discharge into the existing concrete drain. The residence times that can be expected for the biofiltration strips at Altadena Maintenance Station and the SR-91/I-605 Separation will reduce from approximately 2 minutes and 8 minutes to 1 minute and 3 minutes, respectively. No mechanism is provided to divert flows in excess of the water quality volume from entering the biofiltration strips.

4.2.3 Biofiltration Swales

As presented in Appendix B, a 25 year storm event will increase the peak flow at each of the four biofiltration swale sites by a factor of 9, and the velocity by a factor of 2. The maximum depth of flow in the swales during the 25 year event is calculated to be between 77 and 185 mm. Given that the swale designs are based on channel depths of at least 250 mm, the larger flows will be contained within the biofiltration swales. No overflowing along the sides is expected. The residence times will however decrease significantly. As with the biofiltration strips, no mechanism is provided for flows in excess of the water quality volume to bypass the biofiltration swales.

4.2.4 Drain Inlet Inserts

As presented in Section 3, the largest peak flow to be expected at the Drain Inlet Insert sites from a 1-year event is only 0.014 m^3/sec (0.49 cfs). A 25 year storm will generate peak flows up to 0.148 m^3/sec (5.18 cfs), roughly 10 times the water quality design amount. The higher peak flows will enter the BMPs through the drain inlet; they are not designed to bypass the facilities. However, the manufacturer’s designs of the inserts includes an overflow mechanism. Once the level of runoff reaches a certain height with the insert, any additional runoff overflows the insert and is discharged into the drain inlet, untreated. Given that any storm drain piping being replaced at all maintenance stations is being replaced with pipe of the same diameter, the retrofit program will not compromise the existing hydraulic capacity or functionality of the system.

4.3 Summary of Results

On the basis of the above information, it can be concluded that the above mentioned BMP facilities will be adequate to handle the runoff from a 25 year runoff event, provided that the existing Caltrans facilities are adequate to handle the 25 year event.

A summary of the hydraulic performace results of each BMP type follows.

4.3.1 Infiltration Trench

The water quality design criteria satisfy the hydraulic design for the infiltration trench.

4.3.2 Biofiltration Strips

Stability calculations, in accordance with the procedures presented in Horner (1996) demonstrate that the flow capacity of the Biofiltration Strips is greater than the stability check design storm flow rate in both cases. The results of the calculations are as follows:

BMP Location	Flow capacity m^3/sec	25-yr Discharge m^3/sec
Altadena MS	0.380	0.155
SR-91/I-605 Separation	0.092	0.037

4.3.3 Biofiltration Swales

Stability calculations, in accordance with the procedures presented in Horner (1996) demonstrate that, in all cases, the flow capacity of the swales is greater than the stability check design storm flow rate. The results of the calculations are as follows:

BMP Location	Flow capacity m^3/sec	25-yr Discharge m^3/sec
SR-91/I-605 Separation	0.590	0.018
SR-91/Cerritos MS	0.169	0.036
I-5/I-605 Separation	0.208	0.054
I-605/Del Amo	0.264	0.058

4.3.4 StreamGuard Drain Inlet Inserts

Based on manufacturer literature, the StreamGuard insert has a total capacity of approximately 0.32 m^3/s and an overflow rate of approximately 0.16 m^3/s. The three StreamGuard BMP Pilots all have a design discharge of less than 0.16 m^3/s; therefore, the inserts should not cause any ponding.

4.3.5 Fossil Filter Drain Inlet Inserts

Based on manufacturer literature, the Fossil Filter has an assumed hydraulic capacity (unverified by independent testing) of 0.085 m^3/s. The design discharge rates of the Fossil Filte sites at the Las Flores and Rosemead Maintenance Stations are below this capacity, and therefore no ponding should result. Conversely, the design discharge rate at the Foothill Maintenance Station does exceed the assumed capacity and may cause some ponding during a 25-yr storm.

REFERENCES

Brown and Caldwell, *Caltrans Storm Water Facilities Retrofit Evaluation*, prepared for the California Department of Transportation, Environmental Program, May 1997.

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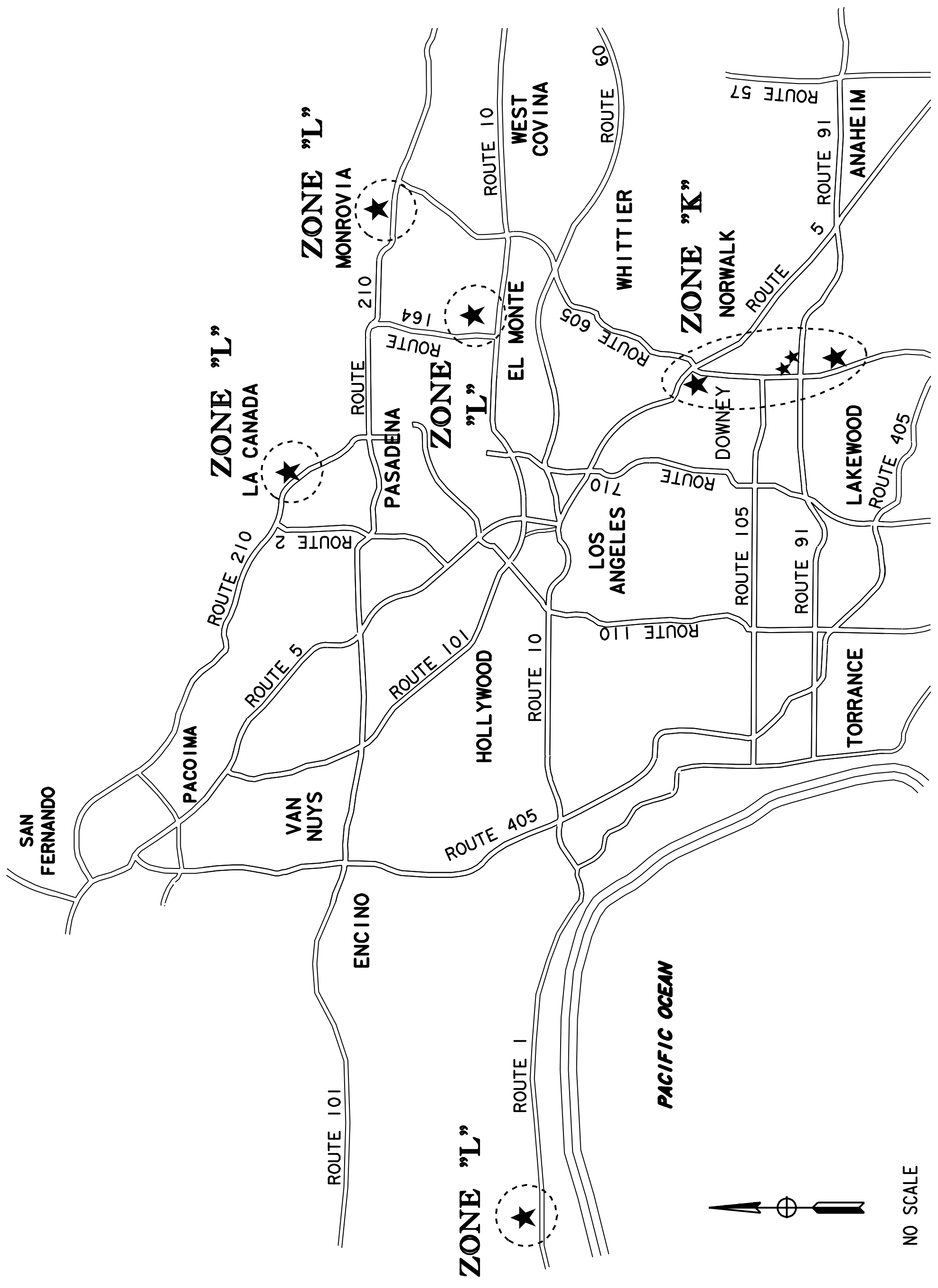
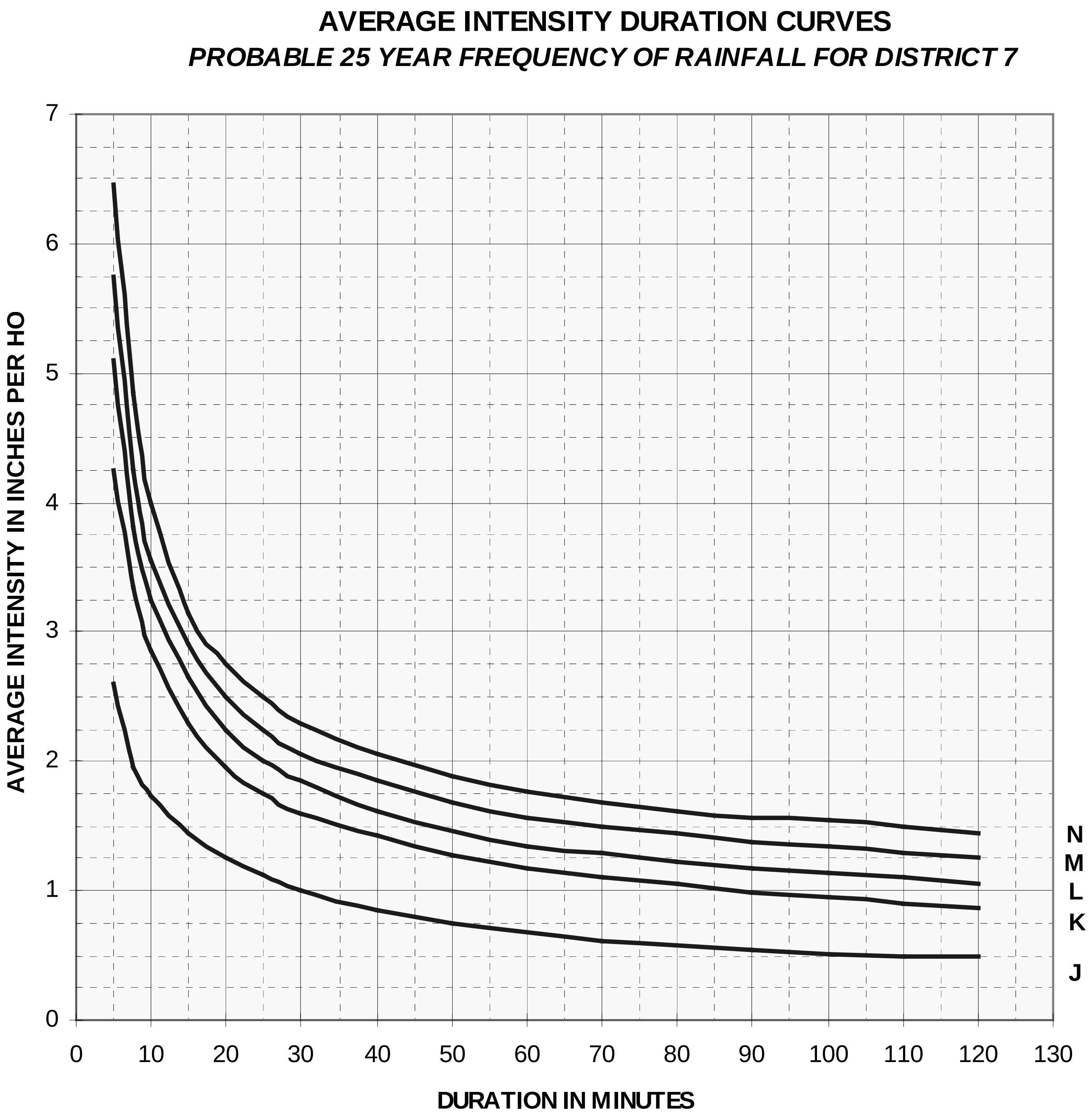
APPENDIX A

HYDROLOGY CALCULATIONS



Note : Information provided by Mr. Keith Lilley, Los Angeles County Department of Public Works

BMP SITE RAINFALL ZONES


AVERAGE INTENSITY DURATION CURVES
PROBABLE 25 YEAR FREQUENCY OF RAINFALL FOR DISTRICT 7
AVERAGE INTENSITY IN INCHES PER HO
DURATION IN MINUTES
0
1
2
3
4
5
6
7
0
10
20
30
40
50
60
70
80
90
100
110
120
130
N
M
L
K
J

APPENDIX B

HYDRAULIC CALCULATIONS

BIO-STRIP CALCULATIONS FOR 1-YEAR EVENT

Manning's Formula for Biofiltration Strip:

$$y = (Qnw^{-1}S^{-0.5})^{0.6}$$

where: y = depth of flow, meters
Q = Peak rate of flow, cubic meters per second
n = Manning's n
w = wifth of strip, m
S = Slope of strip

A. Calculation of Required Width (T_r) for 0.5 inch Depth of Flow

Site	Q (m^3/s)	n	S	y (m)	T_r (m)
Altadena Maint. Station	0.033	0.2	3%	0.013	55.436
SR-91/I-605 Separation	0.004	0.2	2%	0.013	8.509

B. Calculation of Actual Depth of Flow for Set Width (T_s)

Site	Q (m^3/s)	n	S	y (m)	T_s (m)
Altadena Maint. Station	0.033	0.2	3%	0.0234	20.000
SR-91/I-605 Separation	0.004	0.2	2%	0.0039	60.000

C. Calculation of Actual Depth of Flow (y) for Specified Strip Width:

Site	Q (m^3/s)	n	S	w (m)	y (m)
Altadena Maint. Station	0.033	0.2	3%	20.0	0.023
SR-91/I-605 Separation	0.004	0.2	2%	60.0	0.004

D. Calculation of Actual Cross Sectional Area (A) and Velocity (V):

Site	Q (m^3/s)	y (m)	w (m)	A (m^2)	V (m/s)
Altadena Maint. Station	0.033	0.023	20.0	0.468	0.070
SR-91/I-605 Separation	0.004	0.004	60.0	0.237	0.017

E. Calculation of Required Length to Achieve 9 min Residence Time:

Site	V (m/s)	T (sec)	L (m)
Altadena Maint. Station	0.070	540	37.8
SR-91/I-605 Separation	0.017	540	9.4

F. Calculation of Actual Residence Time (T):

Site	V (m/s)	L (m)	T (min)
Altadena Maint. Station	0.070	8	1.9
SR-91/I-605 Separation	0.017	8	7.7

BIO-STRIP STABILITY CALCULATIONS FOR 25-YEAR EVENT

Vegetation Coverage	Good
Average Grass Height (in)	6-10
Degree of Retardance	Moderate (C)
Max. Permissible Velocity (m/s)	1.2

A. Calculation of Actual VR

Site	n	s	VR (m^2/s)	R (m)	VR (m^2/s)
Altadena Maint. Station	0.048	3.0%	0.242	0.201	0.248
SR-91/I-605 Separation	0.045	2.0%	0.279	0.232	0.274

B. Calculation of Actual V

Site	VR	R	V
Altadena Maint. Station	0.248	0.201	1.23
SR-91/I-605 Separation	0.274	0.232	1.18

C. Calculation of A_s

Site	Q (m^3/s)	V (m/s)	A_s (m^2)	A_d (m^2)	$A_s < A_d$
Altadena Maint. Station	0.155	1.23	0.126	0.468	yes
SR-91/I-605 Separation	0.039	1.18	0.033	0.237	yes

D. Calculation of Depth of Flow

Site	A_s (m^2)	T (m)	y_s (m)
Altadena Maint. Station	0.126	20.0	0.0063
SR-91/I-605 Separation	0.033	60.0	0.0006

E. Final Capacity Check

Site	T (m)	Y (m)	A (m^2)	R	Q (m^3/s)
Altadena Maint. Station	20.0	0.102	2.032	0.102	0.3803
SR-91/I-605 Separation	60.0	0.025	1.524	0.025	0.0920

BIO-SWALE CALCULATIONS FOR 1-YEAR EVENT

Manning's Formula for Biofiltration Swale :

$$w_b = Qny^{-1.67}S^{-0.5} - zy$$

where: Q = Peak rate of flow, cubic meters per second
n = Manning's n, assumed at 0.2
y = depth of flow, meters
S = Slope of channel bottom
z = slope of channel side walls in form z:1

A. Calculation of Minimum Bottom Width (w_b) for 3 inch (0.076 m) depth of flow:

Site	Q (m^3/s)	z	S	y (m)	w_b (m)
SR-91/I-605 Separation	0.002	4	2.0%	0.076	-0.11
SR-91/Cerritos MS	0.004	2	2.0%	0.076	0.25
I-5/I-605 Separation	0.007	2	2.0%	0.076	0.63
I-605/Del Amo	0.006	2	2.0%	0.076	0.48

B. Min. & Max. Permissible Widths and Specified Design Swale Bottom Width:

Site	Min (m)	Max (m)	w_b (m)
SR-91/I-605 Separation	0.6	2.4	1.5
SR-91/Cerritos MS	0.6	2.4	1.5
I-5/I-605 Separation	0.6	2.4	2.0
I-605/Del Amo	0.6	2.4	1.0

C. Calculation of Actual Depth of Flow (y) for Specified Bottom Width:

Site	Q (m^3/s)	z	S	w_b (m)	y (m)
SR-91/I-605 Separation	0.002	4	2.0%	1.500	0.021
SR-91/Cerritos MS	0.004	2	2.0%	1.500	0.033
I-5/I-605 Separation	0.007	2	2.0%	2.000	0.042
I-605/Del Amo	0.006	2	2.0%	1.000	0.054

D. Calculation of Actual Cross Sectional Area (A) and Velocity (V):

Site	Q (m^3/s)	y (m)	w_b (m)	A (m^2)	V (m/s)
SR-91/I-605 Separation	0.002	0.021	1.500	0.034	0.054
SR-91/Cerritos MS	0.004	0.033	1.500	0.052	0.073
I-5/I-605 Separation	0.007	0.042	2.000	0.088	0.085
I-605/Del Amo	0.006	0.054	1.000	0.060	0.100

E. Necessary Swale Lengths (L) for 5 and 9 min Residence Times:

Site	V (m/s)	L_5 (m)	L_9 (m)
SR-91/I-605 Separation	0.054	16	29
SR-91/Cerritos MS	0.073	22	39
I-5/I-605 Separation	0.085	25	46
I-605/Del Amo	0.100	30	54

F. Available Site Length and Specified Design Length:

Site	Avail. (m)	L (m)
SR-91/I-605 Separation	60	40
SR-91/Cerritos MS	20	20
I-5/I-605 Separation	40	40
I-605/Del Amo	55	54

G. Calculation of Actual Residence Time (T):

Site	V (m/s)	L (m)	T (min)
SR-91/I-605 Separation	0.054	40	12.4
SR-91/Cerritos MS	0.073	20	4.6
I-5/I-605 Separation	0.085	40	7.9
I-605/Del Amo	0.100	54	9.0

BIO-SWALE STABILITY CALCULATIONS FOR 25-YEAR EVENT

Vegetation Coverage	Good
Average Grass Height (in)	6-10
Degree of Retardance	Moderate (C)
Max. Permissible Velocity (m/s)	1.5

A. Calculation of Actual VR

Site	n	s	VR (m^2/s)	R (m)	VR (m^2/s)
SR-91/I-605 Separation	0.040	2.0%	0.418	0.279	0.419
SR-91/Cerritos MS	0.040	2.0%	0.418	0.279	0.419
I-5/I-605 Separation	0.040	2.0%	0.418	0.279	0.419
I-605/Del Amo	0.040	2.0%	0.418	0.279	0.419

B. Calculation of Actual V

Site	VR	R	V
SR-91/I-605 Separation	0.4187	0.279	1.50
SR-91/Cerritos MS	0.4187	0.279	1.50
I-5/I-605 Separation	0.4187	0.279	1.50
I-605/Del Amo	0.4187	0.279	1.50

C. Calculation of A_s

Site	Q (m^3/s)	V (m/s)	A_s (m^2)	A_d (m^2)	$A_s < A_d$
SR-91/I-605 Separation	0.018	1.50	0.012	0.034	yes
SR-91/Cerritos MS	0.036	1.50	0.024	0.052	yes
I-5/I-605 Separation	0.054	1.50	0.036	0.088	yes
I-605/Del Amo	0.058	1.50	0.038	0.060	yes

D. Calculation of Depth of Flow

Site	A_s (m^2)	w_b (m)	z	y_s (m)	y_d (m)
SR-91/I-605 Separation	0.012	1.5	4.0	0.008	0.021
SR-91/Cerritos MS	0.024	1.5	2.0	0.016	0.033
I-5/I-605 Separation	0.036	2.0	2.0	0.018	0.042
I-605/Del Amo	0.038	1.0	2.0	0.036	0.054

E. Final Capacity Check

Site	w_b (m)	z	Y (m)	A (m^2)	R	Q (m^3/s)
SR-91/I-605 Separation	1.5	4	0.3	1.560	0.4	0.590
SR-91/Cerritos MS	1.5	2	0.3	0.780	0.3	0.232
I-5/I-605 Separation	2.0	2	0.3	0.780	0.2	0.208
I-605/Del Amo	1.0	2	0.3	0.780	0.3	0.264

APPENDIX C

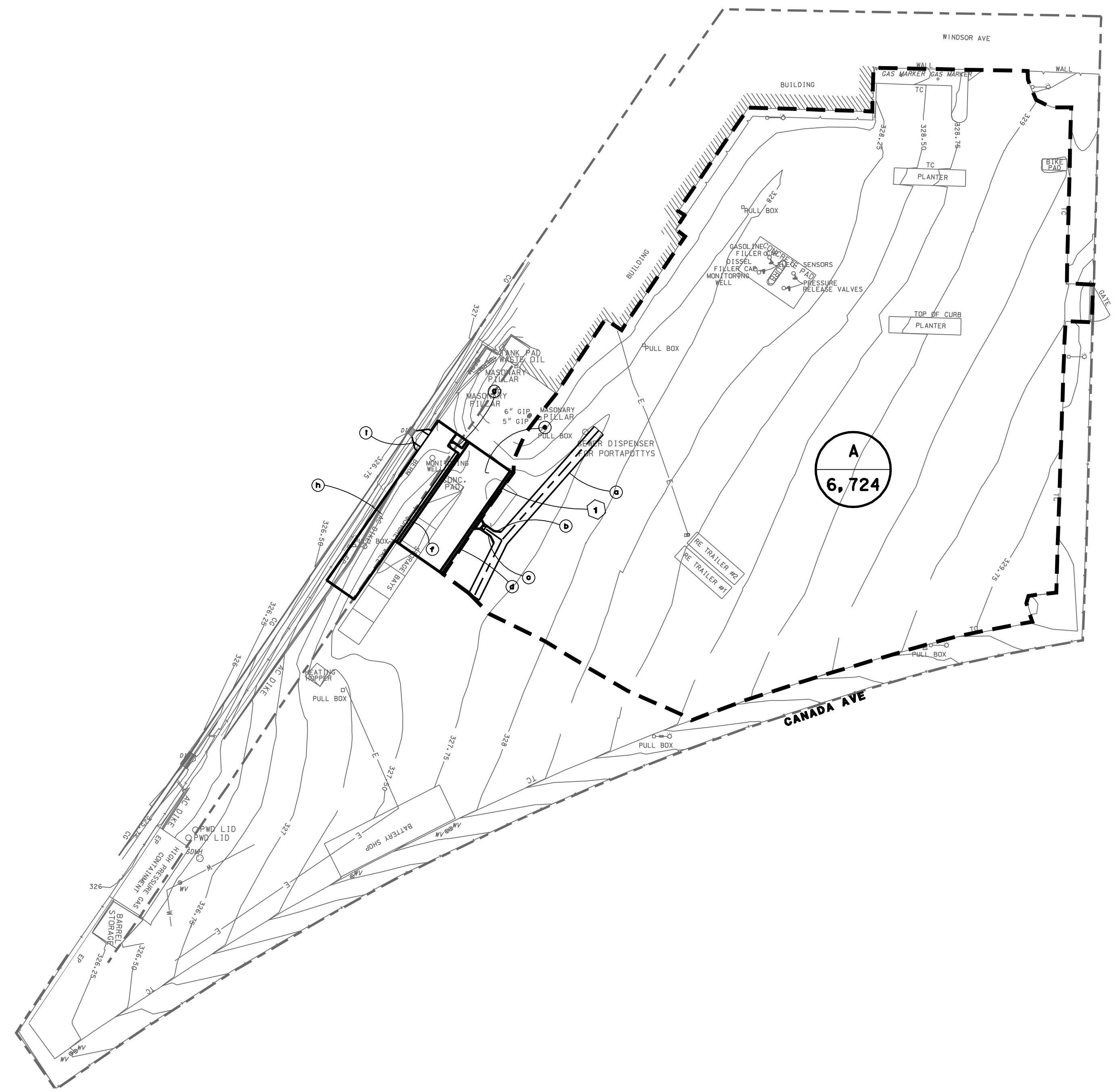
HYDROLOGY MAPS

DIST	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT
07	LA	I,5,91,164 210,605	VAR

MONTGOMERY WATSON - CHAUDHARY
750 B STREET SUITE 1610
SAN DIEGO CA 92101-8131

CALCULATED/ DESIGNED BY	CLP	DATE 7/98	REVISED BY
CHECKED BY	GAF	7/98	DATE REVISED

PROJECT ENGINEER
GARY FRIEDMAN



LEGEND

WATERSHED/SUBAREA

A
100

AREA DESIGNATION
SUBAREA AREA (M^2)

DRAINAGE FACILITY

SITE 1 - ALTADENA MAINTANENCE STATION

ALL DIMENSIONS ARE IN
METERS UNLESS OTHERWISE SHOWN

HYDROLOGY MAP

SCALE 1:500

H-1

FOR REDUCED PLANS ORIGINAL 0 20 40 60 80

USERNAME =>$$$$$$USER$$$$$$

LAST REVISION | DATE PLOTTED => 07-JUN-2000

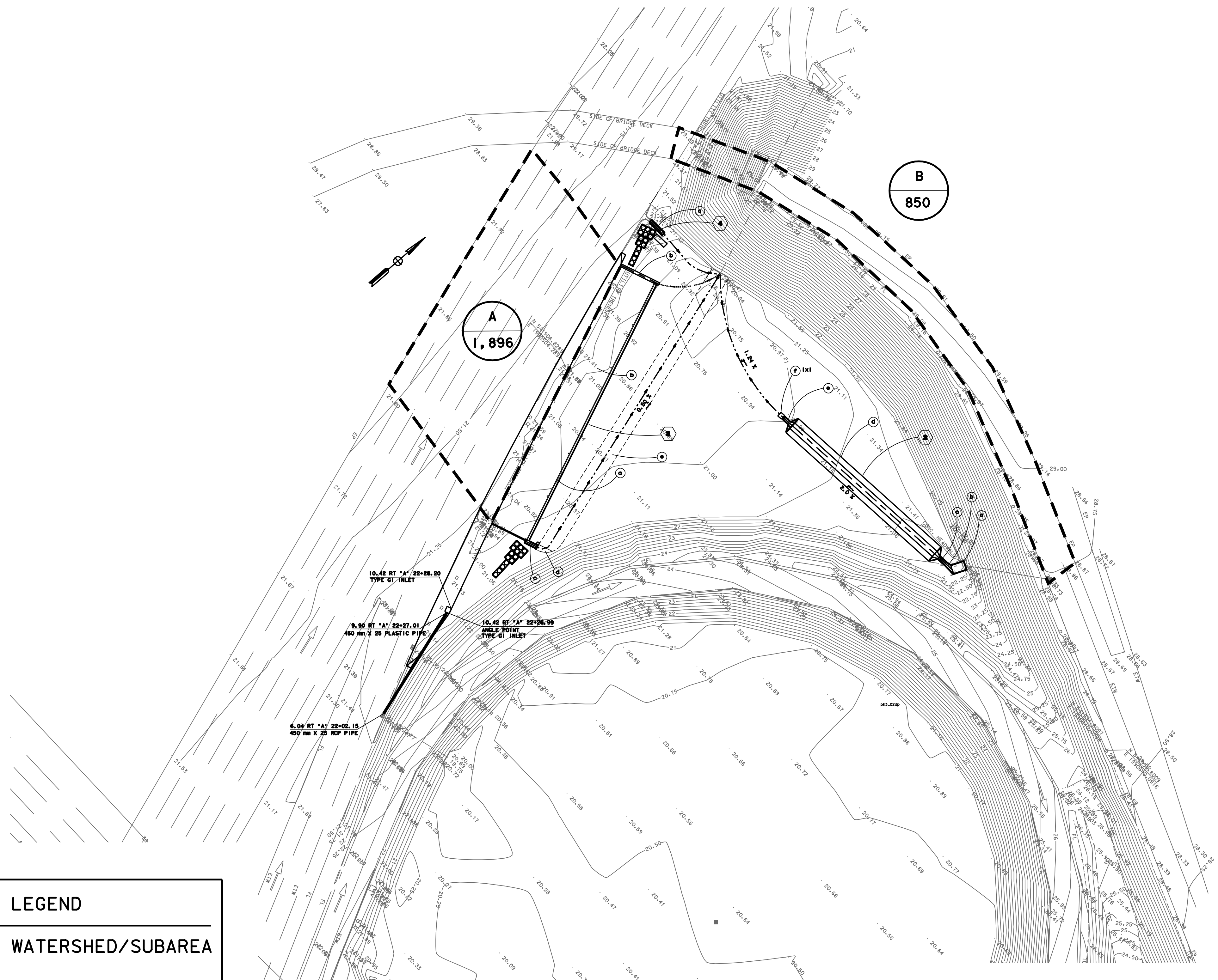
DIST	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT
07	LA	210	VAR

Metric

MONTGOMERY WATSON - CHAUDHARY
750 B STREET SUITE 1610
SAN DIEGO CA 92101-8131

CALCULATED/ DESIGNED BY	CLP	DATE 7/98	REVISED BY
CHECKED BY	GAF	7/98	DATE REVISED

PROJECT ENGINEER
GARY FRIEDMAN



LEGEND

- - - -	WATERSHED/SUBAREA
A / 100	AREA DESIGNATION SUBAREA AREA (M^2)
——	DRAINAGE FACILITY

SITE 2 - SR-91 / I-605 SEPARATION

ALL DIMENSIONS ARE IN
METERS UNLESS OTHERWISE SHOWN

HYDROLOGY MAP

SCALE 1:500

H-2

LAST REVISION
DATE PLOTTED => 07-JUN-2000

FOR REDUCED PLANS ORIGINAL 0 20 40 60 80

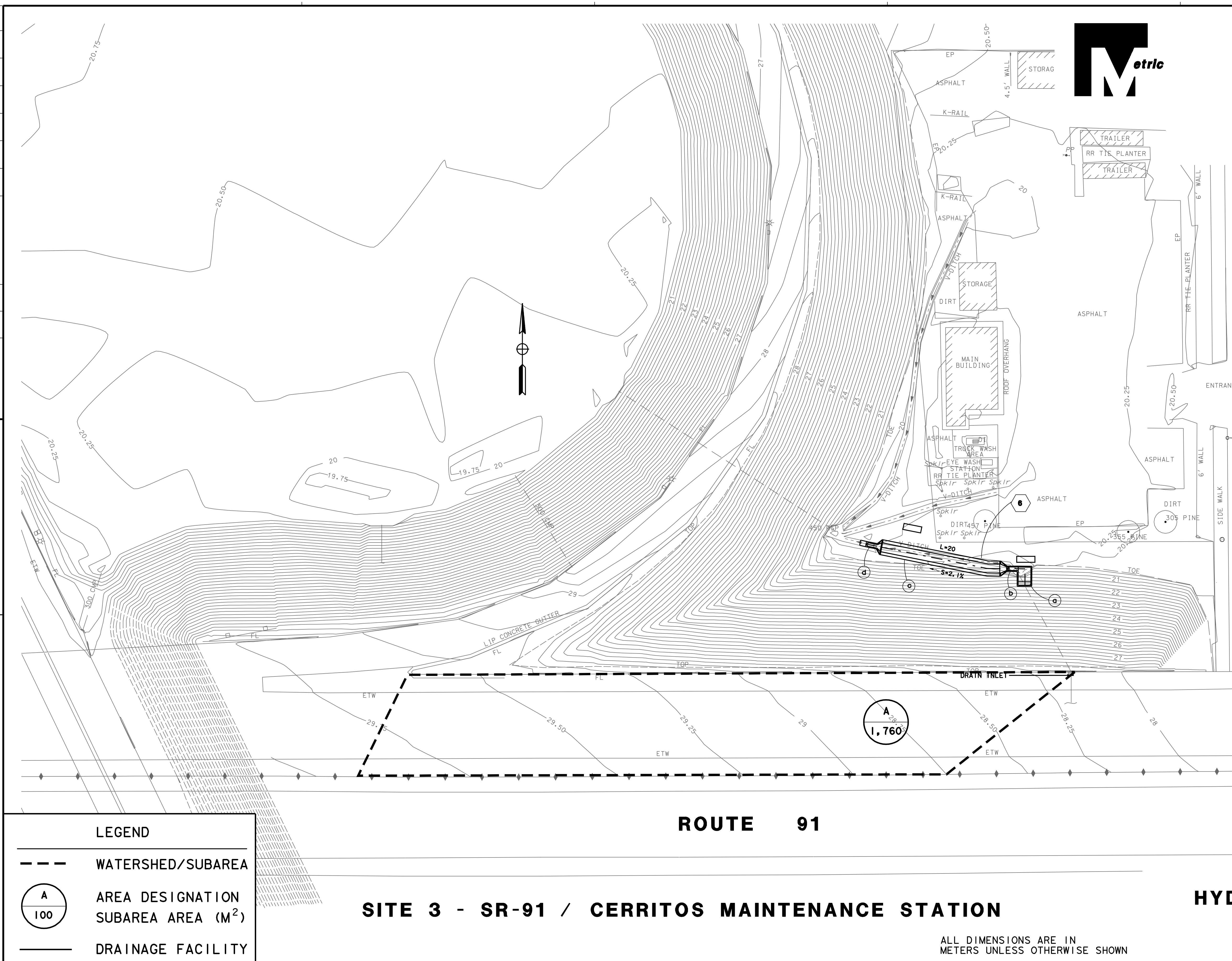
USERNAME => $$$$$$USER$$$$$$

DIST	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT
07	LA	1,5,91,164 210,605	VAR

MONTGOMERY WATSON - CHAUDHARY
750 B STREET SUITE 1610
SAN DIEGO CA 92101-8131

CALCULATED/ DESIGNED BY	CLP	DATE 7/98	REVISED BY
CHECKED BY	GAF	7/98	DATE REVISED

PROJECT ENGINEER: GARY FRIEDMAN



LEGEND

- WATSHED/SUBAREA
- AREA DESIGNATION (A) / SUBAREA AREA (M^2) (100)
- DRAINAGE FACILITY

SITE 3 - SR-91 / CERRITOS MAINTENANCE STATION

HYDROLOGY MAP

SCALE 1:300

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN

H-3

DATE PLOTTED => 07-JUN-2000

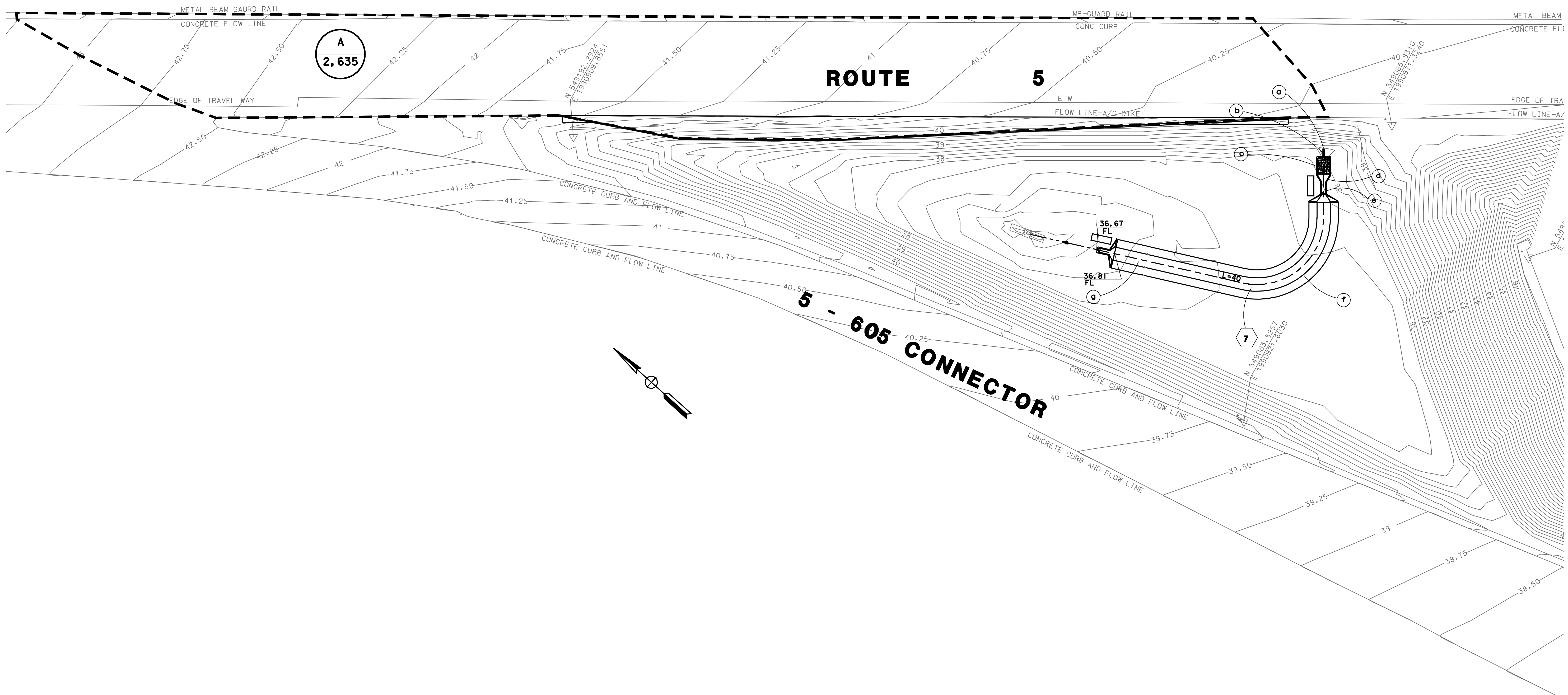
USERNAME => $$$$$$USER$$$$$$

DIST	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT
07	LA	1,5,91,164 210,605	VAR

MONTGOMERY WATSON - CHAUDHARY
750 B STREET SUITE 1610
SAN DIEGO CA 92101-8131

REVISED BY	DATE REVISED
CALCULATED/ DESIGNED BY: CLP	DATE: 7/98
CHECKED BY: GAF	7/98

PROJECT ENGINEER
GARY FRIEDMAN



LEGEND

— — —	WATERSHED/SUBAREA
A / 100	AREA DESIGNATION SUBAREA AREA (M^2)
———	DRAINAGE FACILITY

I-5 / I-605 SEPARATION

HYDROLOGY MAP

SCALE 1:500

ALL DIMENSIONS ARE IN
METERS UNLESS OTHERWISE SHOWN

H-4

DATE PLOTTED => 07-JUN-2000

LAST REVISION

FOR REDUCED PLANS ORIGINAL 0 20 40 60 80

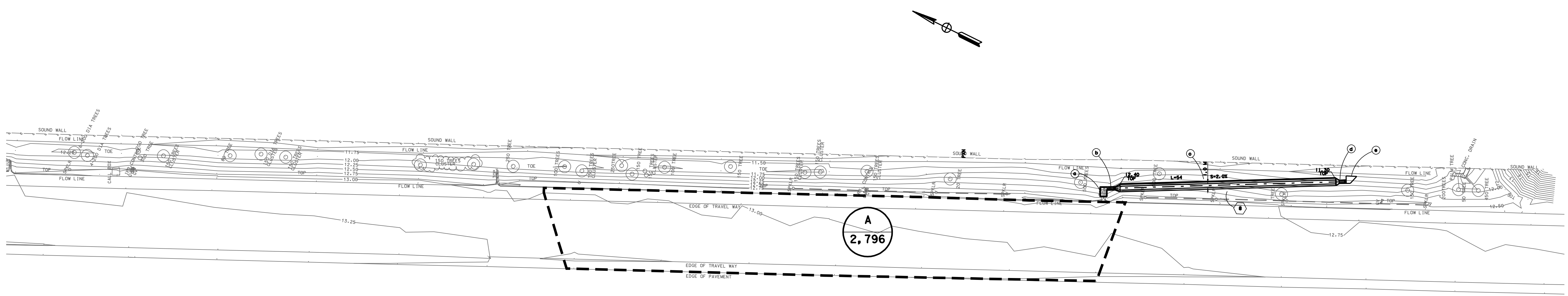
USERNAME => $$$$$$USER$$$$$$

DIST	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT
07	LA	1,5,91,164 210,605	VAR

MONTGOMERY WATSON - CHAUDHARY
750 B STREET SUITE 1610
SAN DIEGO CA 92101-8131

CALCULATED/ DESIGNED BY	CLP	DATE 7/98	REVISED BY
CHECKED BY	GAF	7/98	DATE REVISED

PROJECT ENGINEER
GARY FRIEDMAN



LEGEND

- - - WATERSHED/SUBAREA

A / 100 AREA DESIGNATION SUBAREA AREA (M^2)

—— DRAINAGE FACILITY

SITE 5 - I-605 / DEL AMO

HYDROLOGY MAP

SCALE 1:500

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN

H-5

LAST REVISION 00-00-00 DATE PLOTTED => 07-JUN-2000

FOR REDUCED PLANS ORIGINAL 0 20 40 60 80

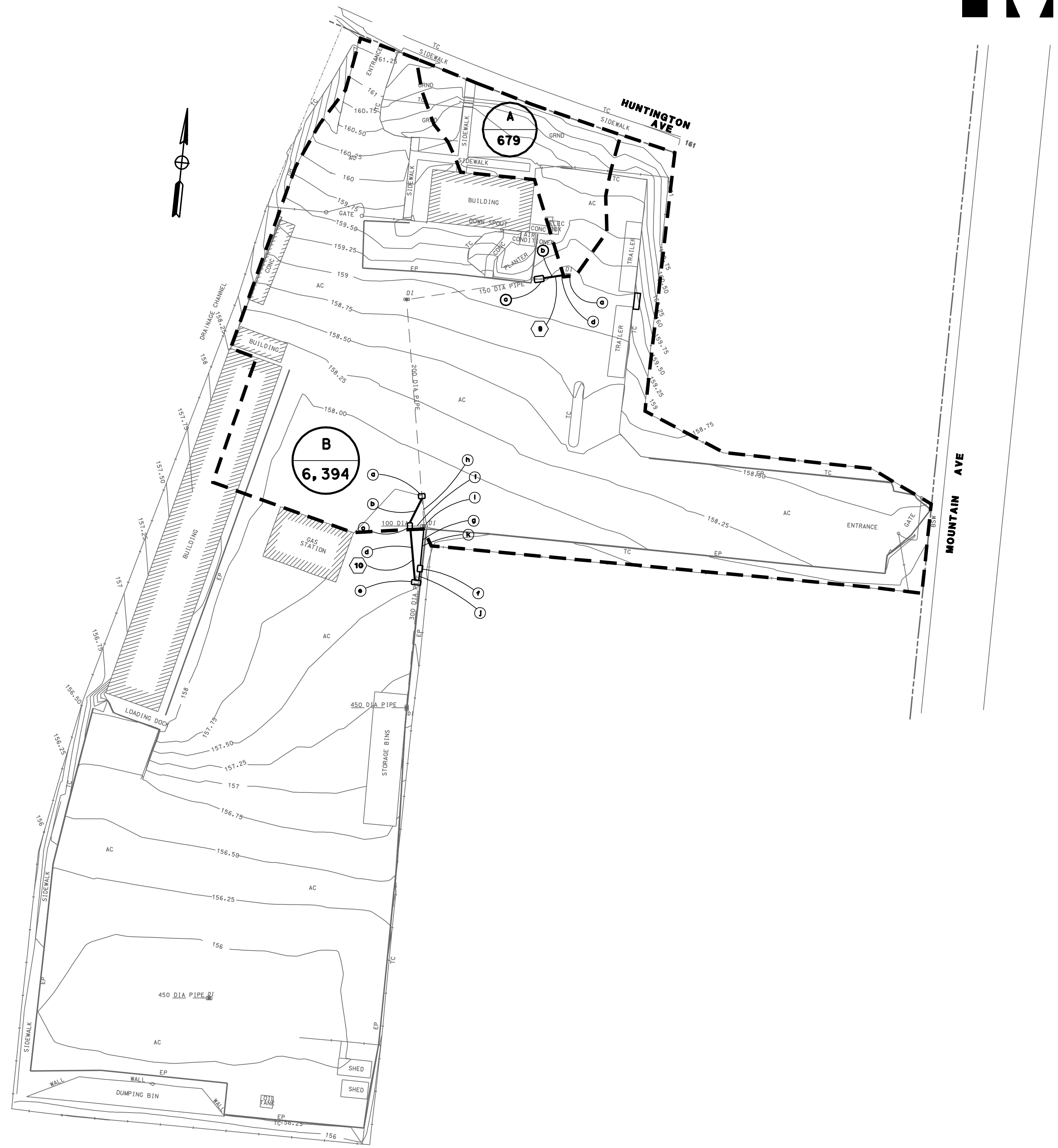
USERNAME =>$$$$$$USER$$$$$$

DIST	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT
07	LA	I,5,91,164 210,605	VAR

MONTGOMERY WATSON - CHAUDHARY
750 B STREET SUITE 1610
SAN DIEGO CA 92101-8131

CALCULATED/ DESIGNED BY	CLP	DATE 7/98	REVISED BY
CHECKED BY	GAF	7/98	DATE REVISED

PROJECT ENGINEER
GARY FRIEDMAN



LEGEND

- - - WATERSHED/SUBAREA

A / 100 AREA DESIGNATION / SUBAREA AREA (M^2)

—— DRAINAGE FACILITY

SITE 6 - FOOTHILL MAINTENANCE STATION

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN

HYDROLOGY MAP

SCALE 1:500

H-6

FOR REDUCED PLANS ORIGINAL 0 20 40 60 80

USERNAME => $$$$$$USER$$$$$$

LAST REVISION

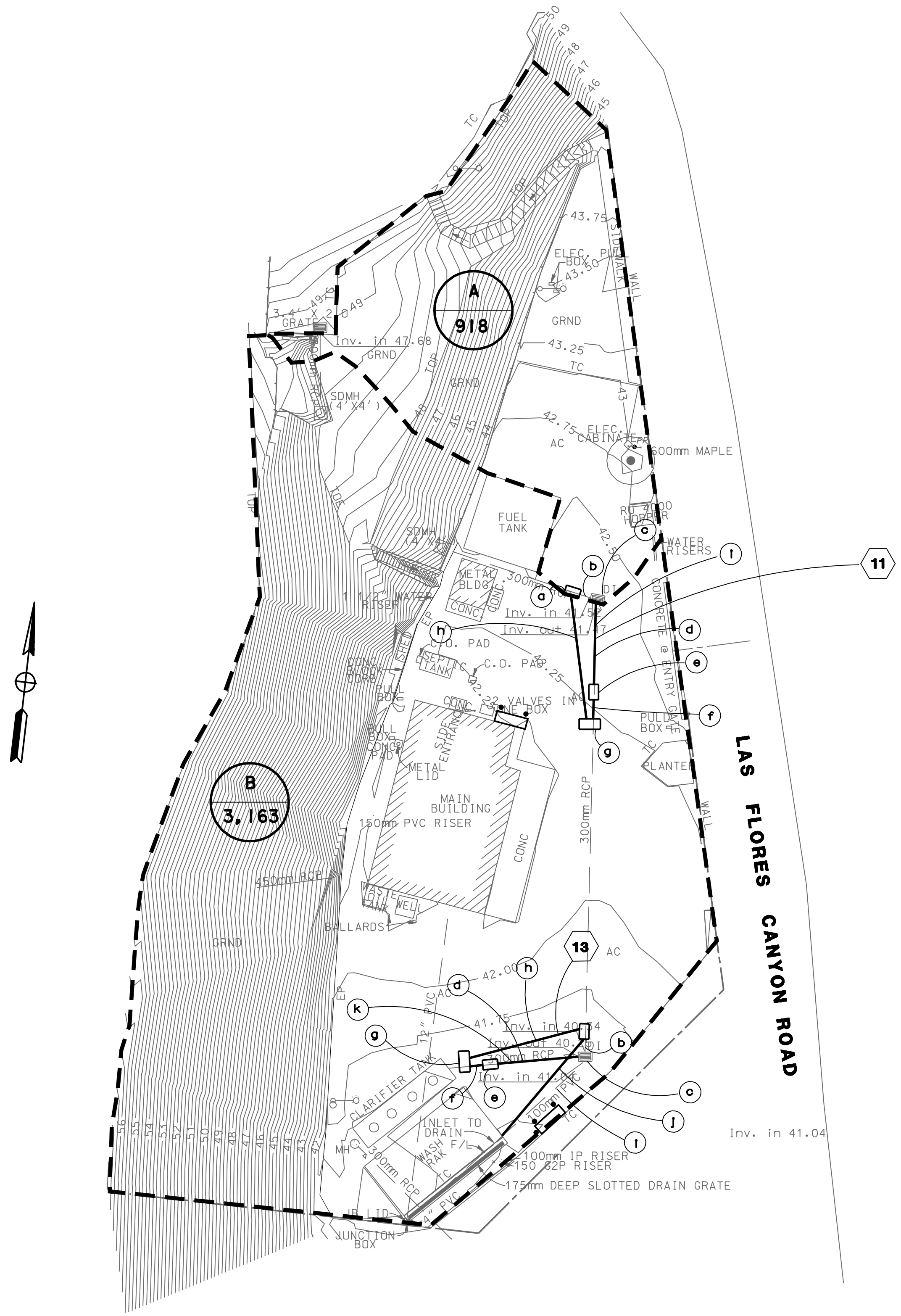
DATE PLOTTED => 07-JUN-2000

DIST	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT
07	LA	1,5,91,164 210,605	VAR

MONTGOMERY WATSON - CHAUDHARY
750 B STREET SUITE 1610
SAN DIEGO CA 92101-8131

CALCULATED/ DESIGNED BY	CLP	DATE 7/98	REVISED BY
CHECKED BY	GAF	7/98	DATE REVISED

PROJECT ENGINEER
GARY FRIEDMAN



LEGEND

WATERSHED/SUBAREA

A / 100 AREA DESIGNATION / SUBAREA AREA (M^2)

DRAINAGE FACILITY

SITE 7 - LAS FLORES MAINTENANCE STATION

ALL DIMENSIONS ARE IN
METERS UNLESS OTHERWISE SHOWN

HYDROLOGY MAP

SCALE 1:300

H-7

FOR REDUCED PLANS ORIGINAL 0 20 40 60 80

USERNAME => $$$$$$USER$$$$$$

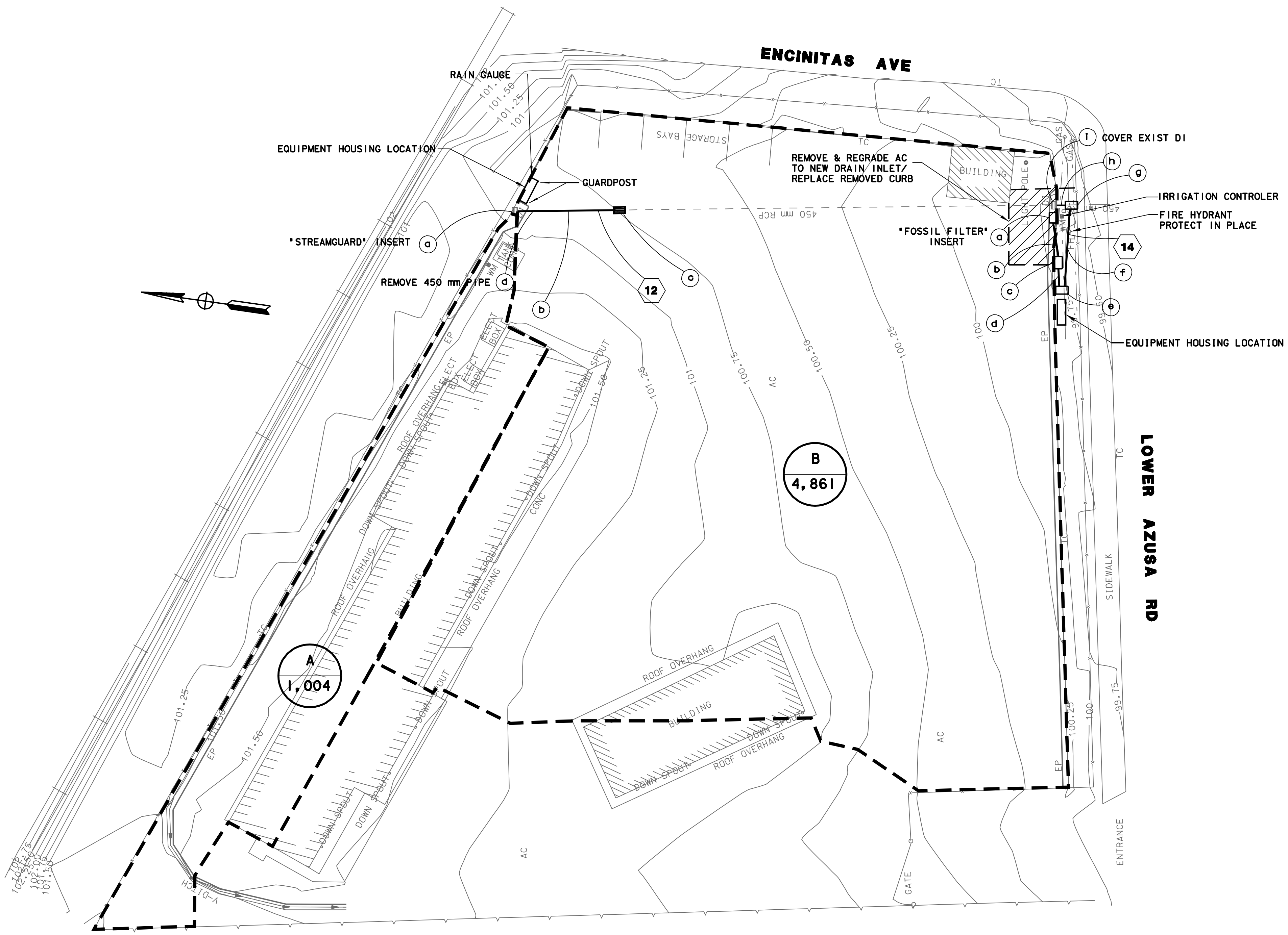
LAST REVISION

DATE PLOTTED => 07-JUN-2000

DIST	COUNTY	ROUTE	KILOMETER POST TOTAL PROJECT
07	LA	1,5,91,164 210,605	VAR

Metric

MONTGOMERY WATSON - CHAUDHARY
750 B STREET SUITE 1610
SAN DIEGO CA 92101-8131



LEGEND	
– – –	WATERSHED/SUBAREA
A / 100	AREA DESIGNATION / SUBAREA AREA (M^2)
——	DRAINAGE FACILITY

SITE 8 - ROSEMEAD MAINTENANCE STATION

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN

HYDROLOGY MAP

SCALE 1:300

H-8

PROJECT ENGINEER	GARY FRIEDMAN
CALCULATED/ DESIGNED BY	CLP
CHECKED BY	GAF
DATE	7/98
REVISED BY	
DATE REVISED	7/98

FOR REDUCED PLANS ORIGINAL 0 20 40 60 80 USERNAME => $$$$$$USER$$$$$$

LAST REVISION DATE PLOTTED => 07-JUN-2000

APPENDIX D

HYDROSEED MIX RECOMMENDATIONS

Martha Blane & Associates
Habitat Restoration Consulting

34123

RECEIVED
MAY 14 1998
ROBERT BEIN, WM FROST

May 12, 1998

Bill Whittenberg
RBF & Associates
14725 Alton Parkway
Irvine, CA 92618

Project: Caltrans Storm Water Management - Retrofit Pilot Study

Subject: Planting Recommendations for Bio-Filter Strips

Dear Bill:

In response to your request, enclosed herein is information on candidate plant species for planting within the bio-filter strips. Per our discussions and the background information you provided, the species chosen must perform certain functions and meet specific criteria, as follows:

- Filter suspended solids within runoff from paved areas
- Withstand one-year storm events
- Adapt to climate conditions within Caltrans Districts 7 and 11
- Tolerate periods of both high and low moisture
- Be low-growing
- Require little or no maintenance

Species that meet these criteria are shown on Table 1 (attached), along with information on plant life form, height, origin, beneficial/detrimental characteristics and comments. *Trifolium willdenovii* (tomcat clover), which was recommended previously by others, is also included on Table 1 for the purpose of comparison.

Leguminous plant species were researched because of their ability to add nitrogen to soils. Few legume species are available that meet the criteria listed above, particularly adaptability (i.e., drought tolerance) and low maintenance (most are annuals that may require replanting). To obtain some benefit from the use of nitrogen-fixing species, it is recommended that annual leguminous species be planted initially, but without expectation for natural reseeding.

P.O. Box 4093 • San Marcos, CA 92069 • Phone: (760) 471-1245 • Fax: (760) 471-7671

In order to increase the likelihood of adequate plant cover in the shortest possible time, while fulfilling the criteria above, it is recommended that a mixture of species be planted together. This approach is also beneficial in reducing the potential for damage from diseases and pests that could occur with a one-species, monoculture type planting.

A recommended mixture of species for planting within the bio-filter strips is shown on Table 2 (attached). The table shows the preferred planting method, material application rates for seeds and container plant densities for plants.

The availability of suitable plant species grown as sod was researched. None of the species shown in Table 1 or 2 are grown as sod since there is not an established market for them and most species are not sod forming. It may be possible to request that some species be contract grown (e.g., saltgrass and creeping wildrye) as sod. However, even if a grower agreed to grow sod, there is high risk for failure since it is not a usual practice.

The plant material that can be obtained in a sod-like form is saltgrass. It is grown in flats (±18" x 18") and may be purchased at Tree of Life Nursery in San Juan Capistrano (714.728.0685). However, as shown in Table 2 and described above, planting "plugs" from cut-up flats, along with other species, is recommended.

All seed and plant materials should be ordered well in advance of need to ensure availability. For example, Tree of Life Nursery currently has ±15 flats of saltgrass available. They indicated that it takes about three months (during the warm season) to grow a flat of saltgrass. The needlegrass species are also currently available, but, availability changes on a daily basis.

Per your request, the seed/plant mixture shown on Table 2 was compared to the seed mix presented in Design Directive Memorandum No. 6 (March 11, 1998) to determine which would be more appropriate for general erosion control. Of the two choices, I believe the seed mix shown in Memo. No. 6 would be the better choice. The reason for this is that there are two shrub species included, along with several grass species and a few legumes. The shrubs are the primary difference, and they will add greater diversity in stature, root system, and possibly the longevity of the plantings.

If you need information on other plant mixtures/assemblages, additional lists could be developed. Please contact me with any questions or comments and/or if you would like further assistance.

Sincerely,

Martha Blane

Martha Blane

Attachments: Table 1
Table 2
References and Sources of Information

TABLE 1
PLANT SPECIES SUITABLE FOR BIO-FILTER PLANTINGS

(Page 1 of 2)

Genus species	Common Name	Life Form	Height	Origin/Range
Bromus carinatus	California brome	grass, perennial, short-lived (± 2 years)	18" - 36"	Western US, British Columbia to Central America
Deschampsia caespitosa	Tufted hairgrass	grass, perennial, clumping	12" - 30"	North America
Distichlis spicata	Saltgrass	grass, perennial, rhizome/stolon forming	6" - 20"	North America to South America
Elymus glaucus	Blue wildrye	grass, perennial, clumping	18" - 36"	Alaska to Baja California
Hordeum brachyantherum	Meadow barley	grass, perennial, clumping	12" - 18"	North America to Baja California
Leymus triticoides "Rio"	Creeping wildrye	grass, perennial, creeping rhizomes	18" - 36"+	Western US and Baja California
Lupinus bicolor	Pygmy-leaf lupine	legume, annual	4" - 12"	California deserts, mountains and coastal areas
Nasella lepida	Foothill needlegrass	grass, perennial, clumping	12" - 24"	Northern California to Baja California
Nasella pulchra	Purple needlegrass	grass, perennial, clumping	12" - 24"	Northern California to Baja California
Trifolium willdenovii	Tomcat clover	legume, annual	4" - 16"	Western North America

TABLE 1
(Continued)

(Page 2 of 2)

Genus species	Common Name	Benefits	Detriments	Comments
Bromus carinatus	California brome	Fast-growing, adapted to drought and poor soils.	Short-lived, may be too tall	Often used for soil stabilization and revegetation.
Deschampsia caespitosa	Tufted hairgrass	Grows in dense stands, adapted to moist soils, recovers well from disturbance.	May be too tall, too dense and require too much moisture.	Important range species, widely distributed, sometimes used for erosion control.
Distichlis spicata	Saltgrass	Stout, hardy, adapts to harsh soil conditions (wet or dry) and silt build-up, recovers well from disturbance.	Foliage may turn brown during coldest months.	Spreads by creeping stolons (similar to Bermuda grass in appearance, but not as vigorous), can form a tough mat-like cover.
Elymus glaucus	Blue wildrye	Fast-growing, fast-spreading, good for erosion control.	May be too tall.	Foliage is bluish-green.
Hordeum brachyantherum	Meadow barley	Fast-growing, begins spring growth early, tolerates moist soils.	May be short-lived.	Can provide cover while slower-growing species become established.
Leymus triticoides "Rio"	Creeping wildrye	Tolerates harsh conditions, heavy soils, forms a dense ground cover, long-lived.	May be too tall and too dense.	Stays green late into summer.
Lupinus bicolor	Pygmy-leaf lupine	Nitrogen-fixing, adapts to many soils, germinates early.	Annual, may not reseed if other vegetation is present.	Frequently included in erosion control and revegetation seed mixes.
Nasella lepida	Foothill needlegrass	Adapted to drought and poor/disturbed soils, long-lived, low fuel.	Best in well-drained soils.	Common component of California grasslands; often used for revegetation.
Nasella pulchra	Purple needlegrass	Adapted to drought and poor/disturbed soils, long-lived, low fuel.	Best in clayey soils.	Major component of California grasslands; often used for revegetation.
Trifolium willdenovii	Tomcat clover	Nitrogen-fixing, adapts to heavy soils, germinates early.	Annual, may not reseed.	Seed recently became available for erosion control and revegetation plantings.

TABLE 2
RECOMMENDED SPECIES MIXTURE FOR BIO-FILTER PLANTINGS(1)

Genus species	Common Name	Seed Application Rate Per Acre %Purity/%Germination	Container Plant Spacing and Container Size/Type
Bromus carinatus	California brome	6.0 pounds per acre 95/80	--
Distichlis spicata	Saltgrass	--	12" on-center spacing of "plugs" from cut-up flats
Deschampsia caespitosa	Tufted hairgrass	1.0 pound per acre 80/60	--
Hordeum brachyantherum	Meadow barley	5.0 pounds per acre 90/80	--
Lupinus bicolor	Pygmy-leaf lupine	3.0 pounds per acre 98/80	--
Nasella lepida	Foothill needlegrass	--	12" on-center spacing of groove tubes (2" deep x 3/4" wide)
Nasella pulchra	Purple needlegrass	--	12" on-center spacing of groove tubes (2" deep x 3/4" wide)
Trifolium willdenovii	Tomcat clover	1.5 pounds per acre 95/75	--

1. Seed and container plant recommendations based on which material will provide the most reliable and fastest cover. Some container species are also available as seed.

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APPENDIX E

ENGINEERING COST ESTIMATE

Engineer's Estimate of Construction

SITE NO.	BMP TYPE	BMP LOCATION	BMP COST
1a	Biofiltration Strip	Altadena Maintenance Station	$234,129
1b	Infiltration Trench	Altadena Maintenance Station	$80,608
2a	Biofiltration Strip	N605/91(N) Interchange	$125,872
2b	Biofiltration Swale	N605/91(N) Interchange	$63,317
3	Biofiltration Swale	West 91 Behind Cerritos MS	$53,441
4	Biofiltration Swale	S5/S605 Interchange	$139,025
5	Biofiltration Swale	N605/Carson & Del Amo Interchange	$131,458
6	Drain Inlet Insert	Foothill Maintenance Station	$38,782
7	Drain Inlet Insert	Las Flores Maintenance Station	$83,323
8	Drain Inlet Insert	Rosemead Maintenance Station	$55,230
TOTAL			**$1,005,185**